Champion International Frenchtown Mill

Discharge Permit MT-0000035

Draft Environmental Impact Statement

Montana
Department of Health
and
Environmental Sciences

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and

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Draft

Environmental Impact Statement

Champion International
Frenchtown Mill

Missoula County

December, 1985

In accordance with the Montana Environmental Policy Act, Section 75-1-101, et. seq., MCA, and the Water Quality Act, Section 75-5-101, et. seq., MCA, and ARM 16.20.901, et. seq., and 16.20.601, et. seq., the following EIS was prepared by the DHES, Environmental Sciences Division, concerning a request for the renewal of Montana Pollutant Discharge Elimination System (MPDES) Permit Number MT-0000035 for the Champion International Frenchtown Mill near Frenchtown, Montana.

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SUMMARY

Keeping the Clark Fork River healthy benefits all concerned. Although the river has had a variety of pollution problems in the past, it has recovered to become an important local and regional resource.

A healthy river also benefits Champion International's Frenchtown Mill in that it is able to accept a certain amount of wastewater from the mill's paper making process.

The mill is economically important not only to the Missoula area, but also to western Montana and northern Idaho. Regionally, it is a cornerstone in the wood products industry, providing a degree of stability to an often fluctuating market.

The Frenchtown Mill is now operating under a two-year discharge permit from the Montana Department of Health and Environmental Sciences (DHES) which allows Champion to directly discharge treated wastewater into the Clark Fork year around according to prescribed conditions. Prior to that, the mill was allowed to discharge wastewater only during high water flows in the spring. Last fall Champion International applied to the DHES for renewal of the present permit, and asked that it be for five years (the standard period of time for discharge permits).

For the past two years the DHES has been conducting an extensive study of the Clark Fork River and its tributaries from Turah to the Montana-Idaho border. Some studies were done by the department, while others were contracted to other agencies and individuals. The studies centered on the quality of water and life associated with the river.

Briefly, the studies revealed:

Nutrients

The highest average nutrient concentrations occur at Turah. However, dilution occurs when the Clark Fork is joined by the Blackfoot and Bitterroot rivers. But, discharges from the Missoula Wastewater Treatment Plant (WWTP) and Champion mill increase the nutrient levels to nearly the concentrations at Turah. Downstream, the Flathead River dilutes the river more, and by the time the water flows through the Thompson Falls, Noxon and Cabinet Gorge reservoirs, most of the nutrients have settled out or dissipated. Only a small percentage of the nutrients reach Lake Pend Oreille, and the lake does not show signs of becoming eutrophied.

Suspended Solids

It appears unlikely that discharges at the maximum allowable rate for total suspended solids would produce a measurable impact on the river or aquatic life. Permitted levels for dissolved oxygen and water color would protect against increasing the volume of suspended solids (loading) during low stream flows.

Dissolved Oxygen

From the information gathered, it appears doubtful that the Champion discharge results in any significant changes in dissolved oxygen concentrations downstream from the mill.

Color

Color is the most important factor in controlling the rate at which Champion can discharge wastewater into the Clark Fork. Ninety-eight percent of all measurements between July 1, 1984 and July 1, 1985 were at or below the permit limit. The measurements exceeding that limit were all one increment greater, and corrective actions were taken immediately.

Toxics

Ammonia and metals in the Champion wastewater discharge do not appear to pose a toxic threat to the Clark Fork. Lack of information concerning resin acids, bioaccumulated acids and sediment-bound acids precludes definite conclusions, but an acute problem seems unlikely. Dissolved sulfides possibly could be a localized problem under certain temperature and pH conditions. Results from several biological tests did not indicate that Champion's wastewater had a toxic affect on aquatic life when concentrations were well above permit limits.

Algae and Aquatic Plants

Wastewater disposal under the provisions of the permit appears to have little affect on algae and aquatic plants.

Macroinvertebrates

The species of macroinvertebrates found by the researchers indicated the river is healthy. The DHES and Champion will continue to sample the Clark Fork.

Aesthetics

The most noticeable problem is the appearance of foam. Although foam cannot be directly attributed to Champion's discharge, steps are being taken to reduce foaming agents in the effluent. Additionally, a number of reported aesthetically unpleasing materials thought to be attributable to Champion, proved to be common organic matter. Colored water from seepage appears in the eight-mile mixing zone between the mill's discharge points and Huson. However, Champion has committed itself to a long-term program aimed at reducing color. Investigations concerning complaints of bad tasting and smelling fish proved inconclusive after two separate taste tests.

Groundwater

Some pollution of the shallow aquifer north of the Frenchtown Mill property has occurred, but further studies will be required to determine the extent of pollution.

Hydrogen Sulfide from Wastewater Ponds

Several ponds in the Champion wastewater treatment system have been identified as producing high concentrations of hydrogen sulfide. If no physical change occurs to the system, violations of the Montana hydrogen sulfide ambient air quality standard will occur. Violations are subject to provisions of the Montana Clean Air Act. The DHES Air Quality Bureau is working with Champion to find ways to reduce the hydrogen sulfide levels.

This DHES' draft environmental impact statement (EIS) on the request by Champion to renew the wastewater discharge permit, discusses each item of concern in detail. As an aid to readers, a glossary is included in the back that defines many of the scientific and technical terms used in this impact statement. Additionally, for those interested in reviewing the technical data that served as a base for the EIS, copies of a two-volume data report have been sent to public libraries in municipalities along the Clark Fork River from Missoula to Sandpoint, Idaho.

If you would like copies (or additional copies) of the draft EIS or have any questions, write: Water Quality Bureau, DHES, Cogswell Building, Capitol Station, Helena, MT, 59620 or call: 444-2406.

DESCRIPTION

Champion International's Frenchtown Mill, situated 15 miles west of Missoula, near Frenchtown on the Clark Fork River (Map No. 1), began operation in 1957, as a joint venture between Waldorf Paper Products Company and Hoerner Boxes, Inc. The mill employed 78 persons, and had a production capacity of 250 TPD (tons per day) of kraft pulp which was shipped in bulk to Waldorf paper mills and container fabricating plants in the Midwest.

The mill's first major expansion occurred in 1960 with the installation of the paper machine and bleach plant. These additions increased production capabilities to 450 TPD of linerboard and 150 TPD of bleached pulp.

In 1966, the mill had a new look and a new name. Waldorf Paper Products Co. and Hoerner Boxes announced their merger and subsequent formation of the Hoerner Waldorf Corporation. A second major expansion of the mill's facilities included the construction of the second paper machine, and two chip digesters.

The next major construction began in 1970. Modification of the #3 recovery boiler, construction of the #4 recovery boiler, and other pollution control measures succeeded in reducing the emission of odorous gases and particulate matter by more than 90 percent.

In 1973, Hoerner Waldorf announced plans for a two-phase expansion that would increase total production, and the DHES produced a draft and final EIS on the project in 1974. Phase I construction began in April of 1976, and was completed in 1978. Major elements of Phase I included a new sawdust digester, improved pulp washing equipment, expansion of the rapid infiltration system (which reduced the amount of effluent being direct discharged into the Clark Fork River), and additional emission control equipment.

Champion International Corporation and Hoerner Waldorf merged in 1977.

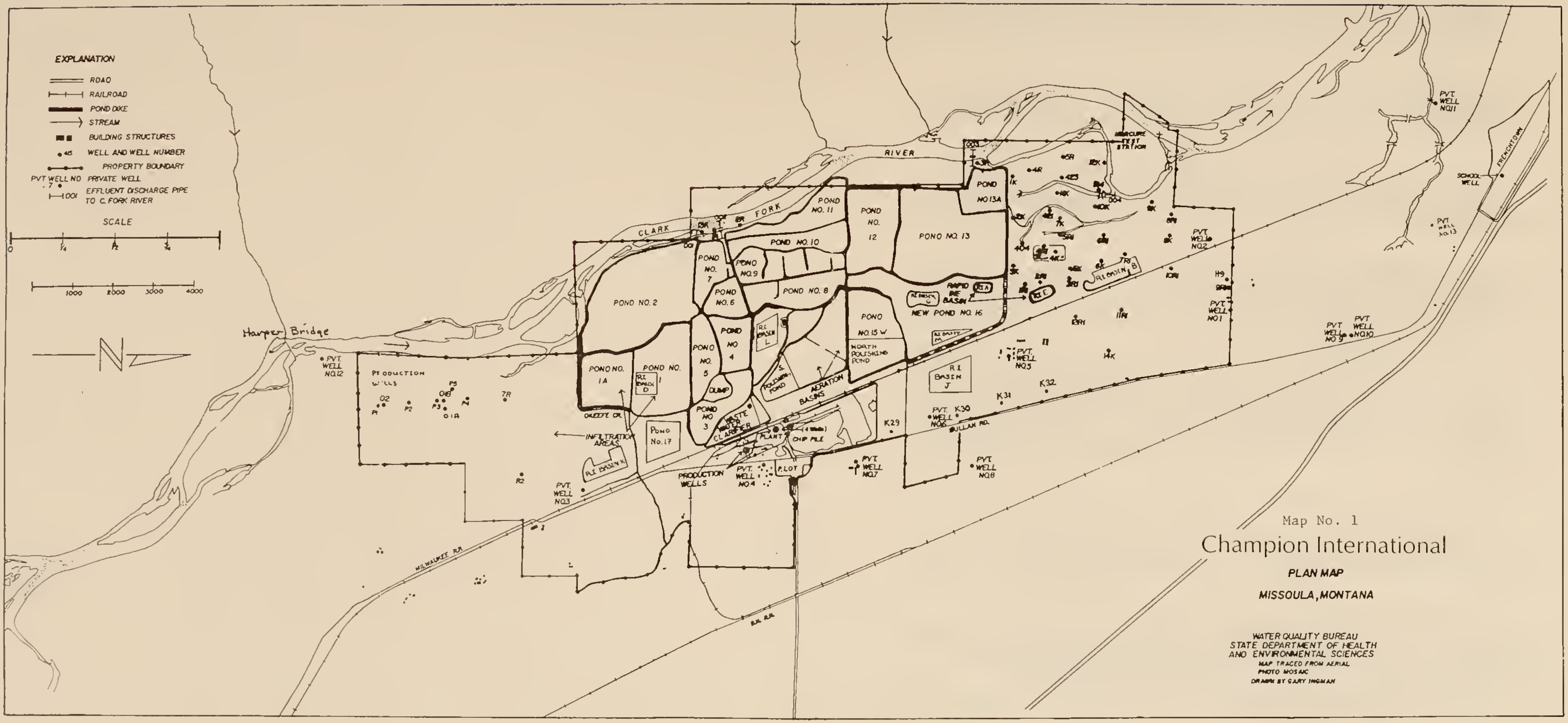
In 1978, construction began on Phase II. Upon completion in December 1980, the mill had a third paper machine, support systems for the machine and pulp mill and a new power boiler, which used waste wood as a primary fuel.

In October 1985 Champion agreed in principal to the proposed sale of the Frenchtown Mill to Stone Container Corporation of Chicago. The sale of the mill is part of a proposed $457 million transaction. The sale is pending the approval of the Stone Corporation's stockholders.

Today, with production capabilities of 1,850 tons per day, the mill is one of the largest in the world.

Process

The creation of linerboard begins when chips and sawdust are brought to Champion in trucks and railroad cars from mills throughout Montana and Idaho. The chips and sawdust are dumped into digesters where steam and a



Map No. 1

Champion International

PLAN MAP

MISSOULA, MONTANA

WATER QUALITY BUREAU
STATE DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES
MAP TRACED FROM AERIAL
PHOTO MOSAIC
DRAWN BY GARY INGMAN

chemical cooking solution, called white liquor, simmer the mixture, breaking down the wood materials into a pulp. The pulp is sent through washers where the non-fibrous materials are flushed out, leaving only wood fiber. From the washers the pulp, which contains about 90 percent water, is pumped into storage tanks.

The pulp stock is pumped to refiners, which improve the bonding quality of the material. At this point it is about 99 percent water. It is then discharged to the headbox of the paper machines. A draining process reduces the moisture content to 80 percent just before the stock moves to the presses, which squeeze more water from the pulp. The stock is then passed through dryers where the remaining water is vaporized. Steel rollers finish the process by pressing the linerboard. The rolls of linerboard are then shipped to customers throughout the nation. At other plants, the linerboard is used to manufacture corrugated boxes, commonly used to ship a variety of other products.

CURRENT ENVIRONMENTAL CONDITIONS

Wastewater treatment has grown along with the Frenchtown Mill. No treatment was provided during the first year of mill operation (1957). A fish kill occurred that summer, and soon after, ponds were constructed and used for treatment. Some of the wastewater seeped from the ponds into the river, and the rest was stored and discharged directly into the Clark Fork during high water in the spring.

Champion has had a wastewater discharge permit since 1968. Prior to that, discharges were negotiated with the mill. Since 1977, Champion's rapid infiltration basins have become progressively plugged, resulting in greater reliance on direct discharge to the Clark Fork as a means of disposing of wastewater. In 1983, Champion applied for a permit which would allow it to directly discharge a portion of the wastewater into the river throughout the year, instead of only during high flows in the spring. This proposal resulted in a great deal of public concern, mostly aimed at the lack of scientific information which was available to support discharging on a year around basis. In response to these concerns, the DHES issued a two-year permit in 1984, and began a number of scientific studies to determine the effects of discharging effluent throughout the year. This EIS discusses those studies.

The DHES received a letter from Champion September 16, 1985, requesting the renewal of the permit. The present permit expires midnight, March 31, 1986.

THE PHYSICAL ENVIRONMENTAL

TERRESTRIAL & AQUATIC LIFE AND HABITATS

The aquatic and terrestrial life in the Clark Fork River and adjacent bottomlands are similar to the native wildlife in similar habitat throughout western Montana.

The predominant big game species is the whitetail deer, according to the Department of Fish, Wildlife and Parks (DFWP). It is common in bottom land areas near the river. Away from the river, as the land changes to

foothills and mountains, the deer species changes from whitetails to mule deer.

There is a resident population of Canadian geese that nest in and around Champion's ponds. Champion uses about 500 acres of ponds as part of their wastewater treatment system. The same is true for a number of different species of ducks. These local populations are supplemented in the fall by numerous migrating birds heading south for the winter. Some of the water fowl winter in the Missoula area, but most go south.

Common aquatic animals include beaver, muskrat and mink. Other small mammals include squirrels, rabbits, rodents and porcupines. The area also supports song birds and has the habitat for upland game birds such as pheasants and ruffed grouse.

Birds of prey include eagles, which occasionally visit the area, but are not known to nest, and Ospreys, which are found near the river, according to the DFWP.

There are no known threatened or endangered species living in the vicinity of the mill, although bald eagles have been periodically observed in the area, according to DFWP.

The "Clark Fork River Fisheries Data Report", prepared by the DFWP, surveyed fish populations near Milltown, Missoula, Huson and Superior. The surveys indicated that mountain whitefish were abundant, rainbow trout common and westslope cutthroat, brown, brook and bull trout were all rare. The report added that all but the bull trout were common in some tributaries of the study area. Northern pike and largemouth bass were also found, but not often. Squawfish and redside shiner were abundant, and other common roughfish included the slimy sculpin, largescale sucker, longnose sucker and longnose dace, according to the report.

More than 200 species of macroinvertebrate animals were collected by the DHES and identified in a special study done for the DHES by Evan and Susanna Hornig. The department sampled above and below the Frenchtown Mill.

In some instances more than 60 different species were identified at a single site. Broad classifications of macroinvertebrates found during the sampling included, midges, mayflies, caddisflies and stoneflies, according to the report. An analysis of this report appears in the Water Quality Section.

VEGETATION COVER, QUANTITY AND QUALITY

The native vegetation in the area of the mill is typical of river bottomland throughout western Montana. The principal trees are cottonwood, with individual trees or small stands of Ponderosa pine scattered here and there. Typical shrubs include willows, wild rose and snowberry; grasses would include bluebunch wheatgrass, Idaho fescue and Columbia needlegrass and common forbs, lupine, yarrow and arrowleaf balsamroot.

The proposed action should not effect terrestrial vegetation. Aquatic vegetation is discussed in the water quality section of the EIS.

GEOLOGY AND SOIL QUALITY, STABILITY AND MOISTURE

The Clark Fork Basin is generally mountainous, but contains four major valleys: the Bitterroot Valley, Blackfoot Valley, Deer Lodge Valley and the Missoula Valley. The basin is bounded by the Continental Divide on the east and south, the Montana-Idaho state line on the west, and the Flathead River-Clark Fork divide to the north.

The Missoula Valley is a wedge-shaped area that includes the Missoula and Ninemile valleys. It has an area of about 180 square miles, and is drained by the Clark Fork River, Ninemile Creek and their tributaries. The climate is semiarid, with an annual precipitation of about 12.8 inches.

The basin was formed during the late Cretaceous (70 million years ago) or early Tertiary time (60 million years ago) in a Precambrian (600 million years ago) sedimentary rock (formed in layers from materials deposited by water, wind or ice). The northeast side of the basin dropped down and was overridden by the southwest side. The basin was subjected to recurring movement until the late Tertiary time (12 to one million years ago). During the middle Tertiary age, the basin was partly filled with possibly as much as 13,000 feet of eroded material, interspersed with layers of volcanic ash. The resulting interbed layers of shale and conglomerate were ultimately covered by a few hundred feet of water deposited gravel and sand during the Pliocene age (12 to one million years ago). Recurring movement around the margins of the basin tilted the strata to the northeast.[1]

The Missoula Basin was flooded and drained during successive glaciations and interglaciations in the Pleistocene Epoch (one million to 25,000 years ago). More than 200 feet of gravel, sand and clay was deposited. The present drainage system has eroded into these deposits.[2]

The Clark Fork River floodplain and low fringing terraces and Ninemile floodplain are covered by eroded material. The high terraces in the Missoula Valley were formed mostly by sediments that were deposited in ancient glacial Lake Missoula. It is believed that the fill reaches maximum depth of 3,000 feet in the central part of the valley and has a total volume of about 25 cubic miles of fill.[3]

The soils in the area of Champion's Frenchtown Mill are classified as those characteristic of floodplains, terraces and alluvial fans. They tend to be level to gently sloping, range from shallow to deep, are well drained and consist of deposits of clay, silt, sand and gravel. These types of soils are particularly important with respect to the mill's ability to use rapid infiltration basins and take advantage of seepage through stratas of sand and gravel.

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1 McMurtrey, R.G. et. al, Geology and Groundwater Resources of the Missoula Basin, Montana, Montana Bureau of Mines and Geology, July 1965, p. 1.

2 Ibid.

3 Ibid.

WATER QUALITY, QUANTITY AND DISTRIBUTION

The Clark Fork River is a tributary of the Columbia River. It gathers its waters from streams draining west-central Montana and sends them westward into Idaho.

Due to the river basin's size and diverse tributaries, it is usually subdivided into the upper Clark Fork and lower Clark Fork basins for discussion purposes, with the division occurring at Milltown Dam, just east of Missoula.

The Upper Clark Fork Basin drains about 6,000 square miles of mountainous terrain, and includes all of Granite County, and portions of Powell, Missoula, Lewis and Clark, Deer Lodge and Silver Bow counties. The Continental Divide forms the basin's northeastern, eastern and southern borders. Most of the western border is the divide of the Sapphire Mountains, and a portion of the northern border extends to the southern end of the Mission and Swan Mountains. The Flint Creek Range and Garnet Range lie within the basin.

The major drainages in the basin are the Clark Fork River and its headwaters, Flint Creek, Rock Creek, the Blackfoot River, and the Little Blackfoot River.

The lower basin is characterized by a broad, flat valley which narrows to a steep-walled valley as it enters Idaho. This area includes most of Lake County, all of Sanders, Mineral and Ravalli counties, and portions of Missoula and Flathead Counties. Major tributaries of the lower mainstem Clark Fork include the Bitterroot River and Flathead River.

Below Milltown Dam, the river discharges about two million acre-feet of water a year into the Missoula Valley, with the Bitterroot River adding another 1.75 million acre-feet.

The Clark Fork has been severely stressed in the past. Mining in several areas in its upper reaches greatly affected water quality, however not all of those problems have been solved or controlled. There continues to be a number of sources of water quality degradation along the river, but the "point source" discharges are controlled by state law.

In the Missoula area, three of the major potential sources of contamination to the river are historic metal deposits upstream from the Milltown Dam, the Missoula wastewater treatment plant (WWTP) and wastewater discharged from the Champion International Mill.

The state has classified the quality of water in the Clark Fork as B-1 from the Missoula area downstream into Idaho. This designation indicates that the water is suitable for drinking, culinary and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary to remove naturally present impurities. It is also acceptable for bathing, swimming, recreation, the growth and propagation of salmonoid fish (trout), waterfowl and furbearers, and for agriculture and industrial use.

Source of Wastewater

The contaminants from the mill which are of principal concern are the dissolved and particulate organic materials. The major sources of organic wastewaters are spent cooking liquors, which originate as spills from pulp washers, evaporators and the weak liquor handling system. The actual papermaking or linerboard process produces a considerable volume of wastewater, but it is relatively low in organic content.

About 25 percent of the color in the wastewater is estimated to be produced in the bleaching process, even though only four percent of the pulp is bleached. Color in pulp and paper mill wastewater is reported to be caused by lignins (a colorless to brown "glue" that holds cellulose fibers together) which have been degraded to various degrees. The wastewater leaving the mill has a color of about 1,500 standard color units (SCU).

Another contaminant that causes some problems within the mill, and perhaps is an aesthetic problem in the river, is foam. The principal sources of foam in kraft pulp mill wastewater are the lignins, resins and fatty acids. Champion is not allowed to discharge foam in other than trace amounts.

Champion summarizes its wastewater treatment data annually in a report to the DHES. For the last period (July 1, 1984 through June 30, 1985) the contaminated flow from the mill to the wastewater treatment facility when the mill was operating was an average of 16.5 million gallons per day (mgd)(the mill was not operating for a total of about 30 days during the period). An additional eight mgd of uncontaminated cooling water bypasses the wastewater treatment system and after passing through a ditch (this reduces temperature) to a low lying area, it enters the Clark Fork River. The wastewater entering the treatment system has a biological oxygen deman (BOD) averaging about 49 pounds of BOD per ton of linerboard produced. BOD is the oxygen needed for decomposition of organic matter in water and is an indicator of the organic content of the wastewater. Environmental Protection Agency (EPA) reported[4] an average of 33.2 pounds of BOD per ton of production for 17 unbleached kraft linerboard mills which it reviewed. A small portion of Champion's pulp is bleached which should add no more than 5 pounds of BOD per ton of total production to the wastewater flow.

Wastewater Treatment System

Wastewater Treatment

Until 1974, the primary means of wastewater treatment was through a ponding system. Some of the wastewater seeped from the ponds while the remainder was discharged directly to the river during high flow in the spring. This system worked well, but the ponds gradually lost some of their seepage capabilities and the ponding area had reached more than 700 acres by 1973.

Seepage water reaching the river should have all the remaining total suspended solids (TSS) and some of the BOD and color removed. Champion

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4 EPA, "Development Document for Effluent Limitations Guidelines and Standards for the Pulp, Paper and Paperboard", EPA 440, 1-82/025, October, 1982.

estimates that the present 508 acres of storage ponds will seep about 11.5 mgd when the ponds are full.

A mechanical clarifier was placed ahead of the ponds in 1970 to remove some of the suspended solids. A dredge had also been utilized in the ponds to try to improve seepage. In 1973 and 1974 a consultant for Champion performed tests to determine the feasibility of rapid infiltration. The tests revealed that the soil was porous enough and the depth to groundwater far enough to enable high rates of wastewater infiltration, thus achieving effective treatment.

The process of rapid infiltration involves adding wastewater to a natural gravel basin and allowing the basin to drain and dry. After it is dry, the basin is not used for a period of time to allow for action by aerobic bacteria (bacteria that need oxygen) to decompose the organic matter left behind and enable the soil to regain some infiltration capacity. The cycle of adding wastewater, draining and drying takes from one to four weeks to complete. About 120 acres of rapid infiltration ponds were constructed. A maximum of 3,400 million gallons (63 percent of the wastewater flow) was disposed of by this means in the one-year period from July 1, 1976 to June 30, 1977. During the same period in 1984-1985, this had dropped to 14 percent of the wastewater flow, due to basins clogging and losing their infiltration capacity. This means of treatment will remove all of the suspended solids, essentially all of the remaining BOD and greater than 75 percent of the color. The best land for rapid infiltration has already been used. The present rapid infiltration area encompasses 90 acres.

During 1974 a system of aerated stabilization basins was added. This system consists of two ponds that retain wastewater a total of about eight days. Twelve 150 horsepower aerators are used. Nutrients in the form of phosphorus and nitrogen compounds are added to improve the biological efficiency of the basins and to stabilize the organic materials. The aerated ponds and subsequent ponding remove greater than 85 percent of the BOD and little of the color before the wastewater is subject to rapid infiltration, seepage or direct discharge. Treatment provided by the aerated system also substantially reduces the foaming tendency of the wastewater.

Figure 1 shows the existing wastewater system.

Table 1 shows the amount of water disposed of by various means and the estimated amount of BOD and total suspended solids (TSS) reaching the river each year.

Figure 2 shows the amount of water that has been discharged to the groundwater through rapid infiltration.

As rapid infiltration has declined, seepage from the storage ponds has increased since these ponds are again being fully utilized. However as rapid infiltration and seepage from the storage ponds further decrease over time, a greater direct discharge can be expected.

Figure 1. Schematic Plan of Champion Wastewater Treatment System

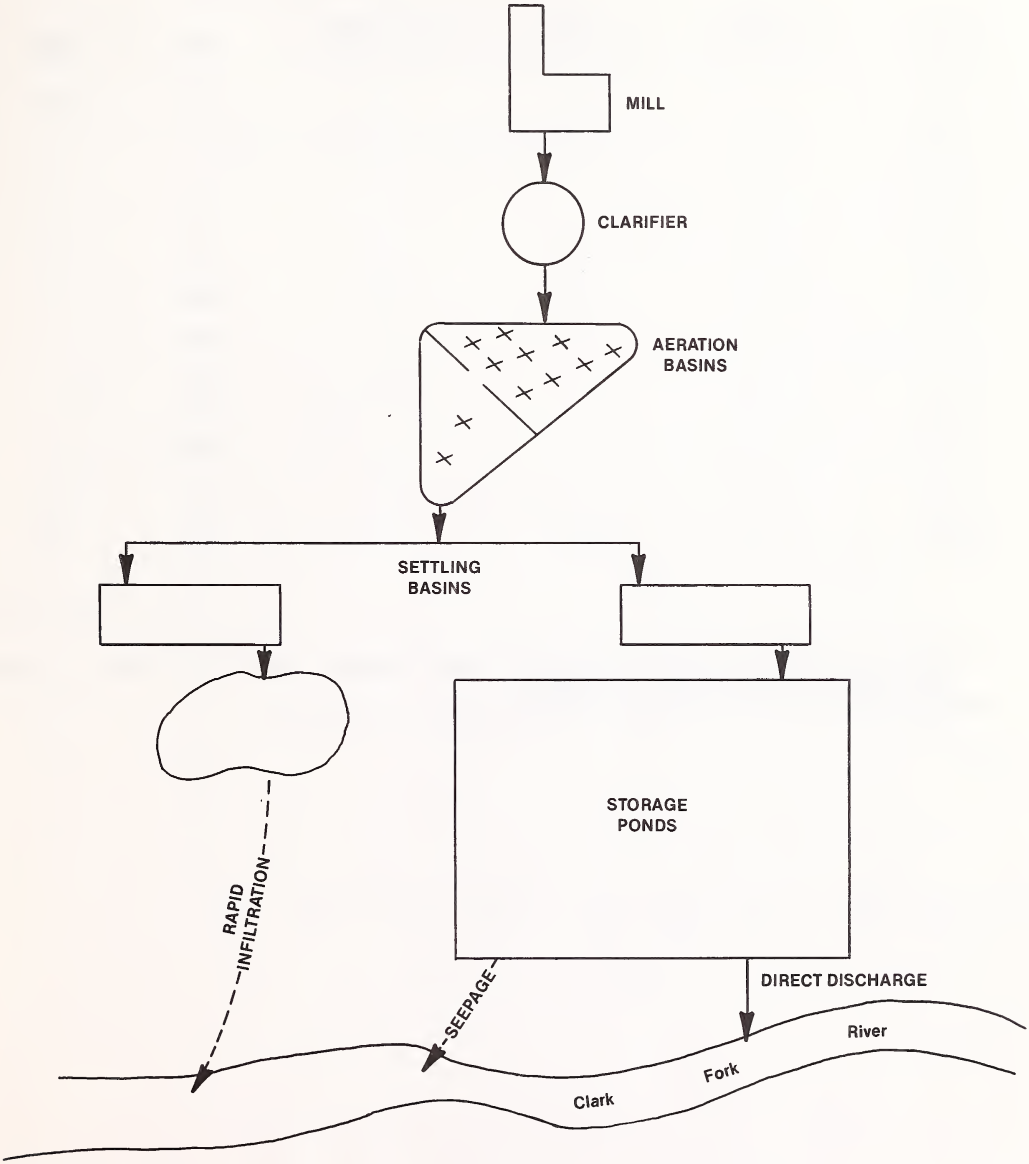


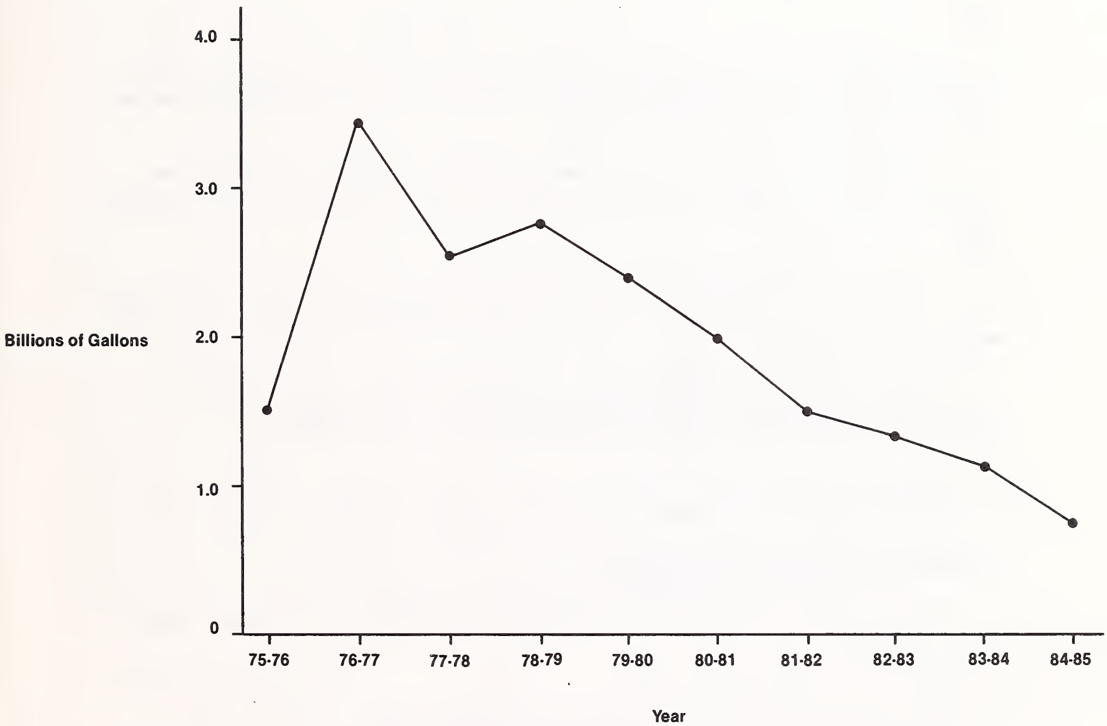
Table 1. Annual Wastewater Effluent Discharge from Champion Mill to Clark Fork River* (Source: Champion's Annual Data Summary)

Year**	Direct Discharge	Rapid Infiltration	Pond Seepage & Evaporation	BOD	TSS
84/85	2.17	0.78	2.59	1.46	1.52
83/84	1.81	1.16	3.05	1.13	1.45
82/83	1.62	1.35	2.37	1.22	2.02
81/82	1.90	1.52	1.50	1.67	1.85
80/81	1.26	1.99	1.68	2.02	1.99
79/80	1.67	2.40	1.13	0.70	0.77
78/79	0.69	2.79	1.56	0.37	0.21
77/78	0.84	2.56	1.35	0.62	0.76
76/77	0.23	3.42	1.62	0.32	0.18
75/76	1.91	1.50	1.85	1.36	1.98

* Direct discharge, rapid infiltration, pond seepage given in billions of gallons, BOD and TSS in millions of pounds.

** Data submitted for the yearly periods July 1 to June 30.

Figure 2. Annual Rapid Infiltration Wastewater Disposal



Wastewater Discharge Permit

The state has had instream standards since 1958 and a wastewater discharge permit program since 1968. Permits that were issued to Champion between 1968 and 1984 allowed direct discharge to the river only during spring runoff. The amount that could be discharged was initially based on the toxicity of the effluent as determined by static bioassays with a safety factor then applied. After aeration was installed in 1974, toxicity was greatly reduced and color became the primary limitation to discharging. In 1984, a two-year permit was issued to Champion for direct discharging throughout the year.

The present permit allows Champion to discharge the following from the ponding and rapid infiltration systems:

BOD:

The total combined annual discharge of BOD shall not exceed three pounds per ton of linerboard production, and in no case shall the annual load of BOD exceed 2,100,000 pounds.

A daily concentration of 161 milligrams per liter (mg/l) and an average 30-day collective concentration of 87 mg/l shall not be exceeded.

TSS:

The annual discharge of TSS (organic and inorganic) shall not exceed 5.7 pounds/ton of linerboard and in no case shall the annual load of TSS exceed 4,000,000 pounds.

A daily maximum concentration of 312 mg/l and an average 30-day collective concentration of 162 mg/l shall not be exceeded.

pH:

The pH of the discharge shall be within the range of 6.0 to 9.0

Floating solids and visible foam:

There shall be no discharge of floating solids or foam other than in trace amounts.

Polychlorinated Biphenols (PCBs):

There shall be no discharge of PCBs.

Color:

The combined discharge shall not cause the instream color measured at Huson--about eight miles below the mill--to exceed instream color at Harper Bridge above the mill by more than five Standard Color Units (SCU). The eight mile reach between the mill and Huson is referred to as the "mixing zone," and is not subject to the color standards.

Dissolved Oxygen:

No discharge shall be permitted when the dissolved oxygen in the river at Harper Bridge or Huson is 7.0 mg/l or below.

In addition there is a restriction on the amount of heat that can be added to the river in the cooling water discharge. The permit also requires monitoring by Champion of the effluent, cooling water, monitoring wells and the river.

The values for BOD and TSS loads, pH and PCBs are the nationwide effluent limitations established by the Environmental Protection Agency (EPA). Instream limitations imposed by the state may require additional treatment.

The discharge of wastewater from the mill to the treatment system is about 16.5 mgd or 25.5 cubic feet per second (cfs). River flow is typically low during late July and August, so only a small amount of direct discharge can enter the river during this time since color is also reaching the river through seepage from rapid infiltration and the storage pond systems. Also during this period the river's dissolved oxygen is at its lowest value and frequently nears 7.0 mg/l. If 7.0 mg/l occurs or if the flow drops below 1,900 cfs, Champion must cease its direct discharge. During the fall and winter months, the depth of wastewater in the storage ponds continues to increase as direct discharge is still limited by color and the river flow remains relatively low. During high river flow in the spring, the ponds can typically be emptied. However, color in the river is still the controlling parameter.

The most immediate concern of Champion is the reduction of color in the wastewater. With an average color in the wastewater of 1,500 SCU, a maximum wastewater flow of 25.5 cfs and an average river flow of 5,500 cfs, the color in the river would be increased 7.0 SCU if all the effluent were directly discharged. With more than 50 percent of the effluent being discharged through rapid infiltration and seepage from the storage ponds and with the color reduction that occurs through this seepage, Champion can presently meet the color discharge limitation. However, a low flow year, along with reduced seepage from the storage ponds and the rapid infiltration systems which can be expected in the future, will cause discharge problems for Champion with the present effluent color concentration.

Treatment Alternatives

In 1984 Champion contracted with Weston, a consulting firm, to review available technologies which may have potential application to Champion's Frenchtown Mill to improve current effluent quality. The executive summary of its report[5] states:

> In 1984, the Frenchtown, Montana, mill of Champion International Corporation (Champion) received a National Pollutant Discharge Elimination System (NPDES) (sic)(Montana Pollutant Discharge Elimination System (MPDES)) Permit to discharge treated wastewaters into the Clark Fork River. The permit allows year around discharge

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5 Weston, "Evaluation of Alternative Technologies for Wastewater Treatment", October 1985.

provided that the receiving stream water quality criteria (sic)(standards) are always maintained.

At the time that the permit was issued, questions concerning the compatibility of year around discharge and receiving stream quality were raised by downstream water users and others. In support of its position to issue the permit, the Montana Department of Health and Environmental Sciences initiated a water quality assessment that was designed to show the need, if any, for further effluent quality enhancement by Champion.

In conjunction with this effort, Champion agreed to conduct a review of available technologies which may have potential application to the Missoula mill site and which can be used to improve current effluent quality, if a need is demonstrated. In order to provide technical input to these studies and to increase public participation, a Clark Fork River Advisory Committee was also formulated consisting of locally interested parties. Champion further agreed to share the technology information with the advisory committee and to encourage the committee members to participate by reviewing the work in a preliminary form and by supplying information and comments that are appropriate for inclusion.

The Roy F. Weston (Weston) consulting engineering company was retained by Champion to perform the technology review. The study was conducted on the assumption that (1) the fundamental manufacturing process (kraft pulping) will remain and (2) the study findings will complement Champion's ongoing inplant efforts and process modifications to reduce waste discharges from the mill. An extensive literature and in-house project record search was conducted to identify alternative wastewater treatment technologies that showed possibilities for installation at the mill. The technologies that were identified were screened to eliminate (1) those that had no proven record of operation, (2) those that had not been proven in the pulp and paper industry, and (3) those that could not produce a better quality effluent than that which is being achieved with the existing facilities.

The permit contains effluent limitations for BOD and suspended solids. The stream water quality limits impose restrictions in incremental color units in the Clark Fork River which can be attributable to the Champion effluent.

Additionally, part of the focus of the state's studies is in the area of nutrients. Accordingly, these four water quality parameters, along with the screening requirements noted in the previous paragraph, were used as the limiting criteria for the technology review.

The treatment techniques that were identified for possible use at the Champion mill are shown in Table 1-1 (Editor's note shown as Table 2 in this EIS) along with their estimated costs and expected performance enhancement capability. Table 1.1 presents capital cost, annual operations and maintenance cost as well as the annual capital costs estimate. The annual capital costs are estimated as follows:

Table 2

TABLE 1.1

Treatment Technologies
for
Effluent Quality Enhancement

Parameter	Technology	Present Permit Limit	Effluent[1] Quality Expected (mg/L)	Capital Cost (million $)	Annual[7] O & M Cost (million $)	Annualized Capital Cost (million $)
BOD		3.0 lbs/ton[3]				
	Existing Treatment		58	N.A.[2]	N.A.	N.A.
	Activated Sludge		30	1.9	0.15	0.45
	Trickling Filter		40	4.1	0.05	0.68
	Zurn - Attisholz		35	2.5	0.67	1.05
SS		5.7 lbs/ton[3]				
	Existing Treatment		64	N.A.		
	Chemically Assisted Clar.		20-30[4]	1.8	0.22	0.5
	(Polymer Addition & Flocculation)		20-30[5]	3.7	0.36	0.94
	Granular Media Filtration		10	2.9	0.29	0.74
	Fine Screening (Microstrainer)		30	2.4	0.68	1.0
Color		Stream increase of 5 scu				
	Existing Treatment		1,200 scu	N.A.		
	Chemically Assisted Clar.[6] (Lime/Polyelectrolyte)		800 scu	3.9	0.36	0.95
Nutrients						
	Existing Treatment		N.A.	N.A		
	Modified Operation		T-N = 5 T-P = 1-2	N.A.	N.A.	N.A.

1. Represents average monthly performance.
2. N.A. - Not Available.
3. Per ton of off-the-machine production.
4. Polyelectrolyte addition to primary clarifier and effluent polishing lagoon are considered for this option.
5. Polyelectrolyte addition to primary clarifier and the installation of a new secondary flocculation clarifier are considered for this option.
6. Additional testing and confirmation is required prior to full-scale application of the CAC process.
7. O&M costs are in addition to present waste treatment costs.

Depreciation (20-year straight line)
Capital recovery factors (20 year life with 8% interest rate; CRF = 0.10185).
Annual operations and maintenance cost.

The above cost items are added to obtain the annual capital costs.

Weston indicated that attempts at color removal by a few pulp mills have not been totally successful and additional research and field testing prior to full-scale application would be needed.

Weston also said that nutrient removal following aerated basin secondary treatment would not be needed if there was good control of nitrogen and phosphorus. It was recommended that a maximum soluble concentration of 5 mg/l of nitrogen and 1 to 2 mg/l of phosphorus be present in the basin effluent. This would amount to about 625 pounds of soluble nitrogen and 125 to 250 pounds of soluble phosphorus in the effluent. Champion's wastewater that was direct discharged during 1984-1985 averaged 15 mg/l of total (soluble and particulate) nitrogen (Kjeldahl) and 3 mg/l of total phosphorus. A portion of the nitrogen and phosphorus remains in an insoluble form in the biological floc (suspended solids) which leaves the aerated basins, but does not totally settle out in the ponds. Improved removal of TSS would also improve the removal of nutrients. This can be accomplished by longer retention time in storage ponds before discharging. The minimum retention time required by the permit is 10 days beyond the retention time afforded by the aeration basins.

Weston also examined the usage of slow rate land treatment (irrigation) and overland flow for disposal. The consultant believes the large land areas needed for these alternatives would make them impractical. Champion further added that suitable land of about 100 acres is available for spray irrigation, but this would only treat about 5 percent of its effluent.

If a need exists for further reduction of wastewater constituents, another alternative is the reduction of inplant losses which enter the wastewater flow. This would reduce the flow, BOD, TSS, color and foaming tendency of the wastewater reaching the treatment system which in turn would be reflected in better effluent quality from the treatment and disposal system. The amount of nutrients added to the treatment system probably could also be reduced because of this control.

Water Quality Studies

In the fall of 1983, the DHES prepared a preliminary environmental review (PER) on the proposed modification of an existing wastewater discharge permit for the Champion Frenchtown Mill. The main question was whether the mill should be allowed to directly discharge treated wastewater into the Clark Fork River throughout the year rather than only during high water periods in the spring.

Following considerable public comment and modification of the PER, the DHES decided to temporarily modify the Champion permit for the period April 1984 to March 1986 to allow a year around discharge and increases in annual loading rates for suspended solids. During that two-year period the DHES

was to conduct a number of scientific studies and produce an EIS prior to any reissuance of the permit in 1986.

Since March of 1984, 18 months have been spent studying the Clark Fork, three of its major tributaries--the Blackfoot, Bitterroot and Flathead Rivers--,discharge points at Champion and the Missoula WWTP and impoundments at Milltown, Thompson Falls, Noxon and Cabinet Gorge. At the same time, the State of Idaho has been conducting investigations on Lake Pend Oreille, which the Clark Fork flows into after leaving Montana.

The DHES studies will continue into the summer of 1987. The information used in the EIS represents scientific findings for the period of early spring 1984 to early fall 1985.

The main objectives of the state's monitoring program are to:

--Establish a base of scientific information for the Clark Fork River in Montana,

--Measure any changes in water quality resulting from modifications in the Champion International Frenchtown Mill wastewater discharge permit and

--Determine the contributions, environmental effects and downstream fate of water quality contaminants from various wastewater sources and tributaries along the river.

The study encompasses about 225 miles of the Clark Fork River from Turah (upstream from Milltown dam) downstream to the Idaho border. The DHES established 31 fixed water quality stations on the river, its four mainstem reservoirs and three major tributaries (Figure 3). In addition, 11 stations were established in deepwater pools between Frenchtown and Thompson Falls Reservoir.

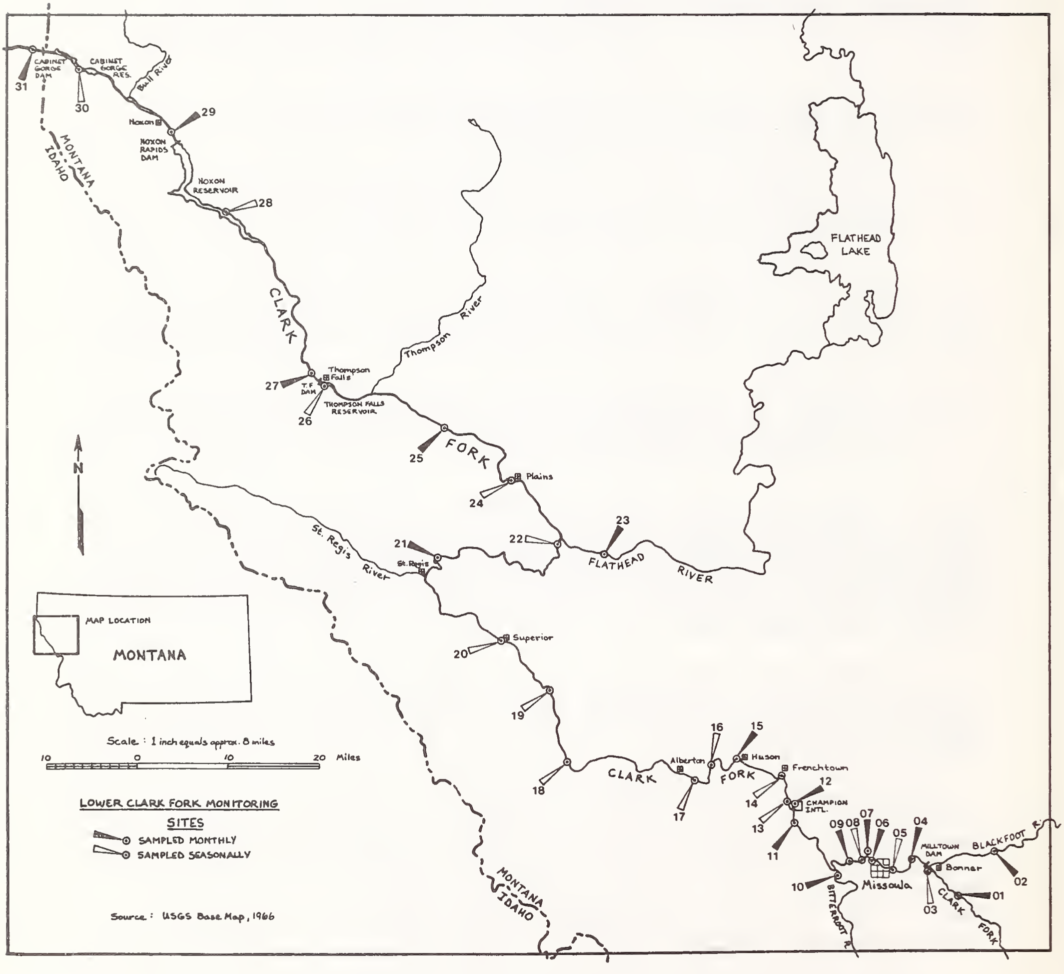
A variety of chemical, physical and biological water quality variables have been measured in the hundreds of samples collected from both shallow waters and from the bottoms of deepwater pools and reservoirs between March 1984 and August 1985.

The results of the scientific studies are reflected in the following discussions. In addition to the discussions, the DHES has published a two-volume data report that includes the actual basic information derived from the various scientific studies. These scientific and technical reports have been sent to public libraries from Missoula to Sandpoint, Idaho to enable interested persons to review the basic information collected by the DHES and others associated with the studies.

Nutrients

The amount of nitrogen and phosphorus in water often controls the amount of algae a river or lake produces. Nutrients are natural components of every aquatic ecosystem. The inherent fertility of a stream, measured in mg/l of nitrogen, phosphorus and other nutrients, is an important factor in fish production.

Figure 3. Map of Study Area Showing Fixed Water Quality Monitoring Stations



But too much of these nutrients, from natural or cultural sources, can produce nuisance growths of algae. In extreme cases, large concentrations of attached or suspended algae can deplete the oxygen dissolved in the water and favor the propagation of "rough" fish over game fish. The scientific term for this phenomenon is eutrophication.

The upper and middle reaches of the Clark Fork are some of the most productive stream waters in Montana west of the Continental Divide from the standpoint of nutrient concentrations and the potential to grow algae (Bahls et al. 1979a, 1979b).

Limiting Nutrients

Of the many nutrients required by algae and other aquatic plants, nitrogen and phosphorus are the two elements usually in the shortest supply in natural waters relative to the needs of the plant. This means that the growth of algae is often directly proportional to the concentration of nitrogen or phosphorus, or both, in the water column (from the bottom of a stream or reservoir to the top of the water).

Mills and others (1982) suggest computing the ratio of total nitrogen (TN) to total phosphorus (TP) in the water to determine which nutrient is limiting. If the ratio is larger than 10, phosphorus is likely limiting; if the ratio is less than 5, nitrogen is likely limiting; if the ratio is between 5 and 10, a determination cannot be made.

TN:TP ratios during the term of the current discharge permit were highly variable in the Clark Fork River at Harper Bridge and at Huson (Table 3). On the average, the river tended to be phosphorus-limited, but there were four times when nitrogen was probably the limiting nutrient (TN:TP ratio less than 5). Although there was no clearcut seasonal trend in TN:TP ratios, they tended to be larger in July and August. These are the months of highest water temperature and the greatest potential for dissolved oxygen problems resulting from algal respiration and decay.

Table 3. Ratios of total nitrogen to total phosphorus concentrations in water samples collected by DHES at Harper Bridge and Huson from March 1984 through August 1985.

	Harper Bridge	Huson
July and August		
Minimum	7.7	7.3
Maximum	38.0	16.3
Mean	18.4	11.7
Median	11.9	11.0
Number of Observations	7	7
All Months		
Minimum	4.3	2.3
Maximum	38.0	16.5
Mean	12.8	9.8
Median	9.8	10.0
Number of Observations	26	26

Algal assays conducted by the U.S. EPA (Greene et al. 1985) and river metabolism studies conducted by the University of Montana (Kicklighter and Stanford 1985) indicate that either nitrogen or phosphorus, or both, may limit the growth of algae in this reach of the river. (See Data Report, Volume 2.) These findings support the conclusions of the DHES as presented in the Champion PER, which were based on data collected by the U.S. Geological Survey (USGS) from 1980 through 1982 at its water quality station below Missoula (Shewman et al. 1984).

Nutrient Application and Loading Trends at Champion International

There is not enough nitrogen and phosphorus in wood to satisfy the needs of the micro-organisms involved in the biological treatment of kraft mill wastewater. Hence both must be added to promote effective biological treatment. The consultant who designed Champion's wastewater treatment system predicted that the company would need to apply 1,870 pounds of nitrogen per day and 485 pounds of phosphorus per day to achieve optimum treatment.

In 1984, Champion added a daily average of 1,833 pounds of nitrogen and 748 pounds of phosphorus to its aeration basin. In 1985 (January through September), the added nutrients were reduced to 1,339 pounds of nitrogen and 533 pounds of phosphorus per day. Nutrient application rates during 1984-1985 averaged 1622 pounds per day and 656 pounds per day, respectively. The figures for 1984 are all-time high application rates since Champion began the practice of adding nutrients in 1975 (Figures 4 and 5). Current nutrient loading rates to the Clark Fork River from Champion discharge and seepage are also at all-time highs (Figures 4 and 5) but are less than those predicted in the PER (Shewman et al. 1984).

Figure 4. Nitrogen (N) application and loading rates at Champion International since 1975.

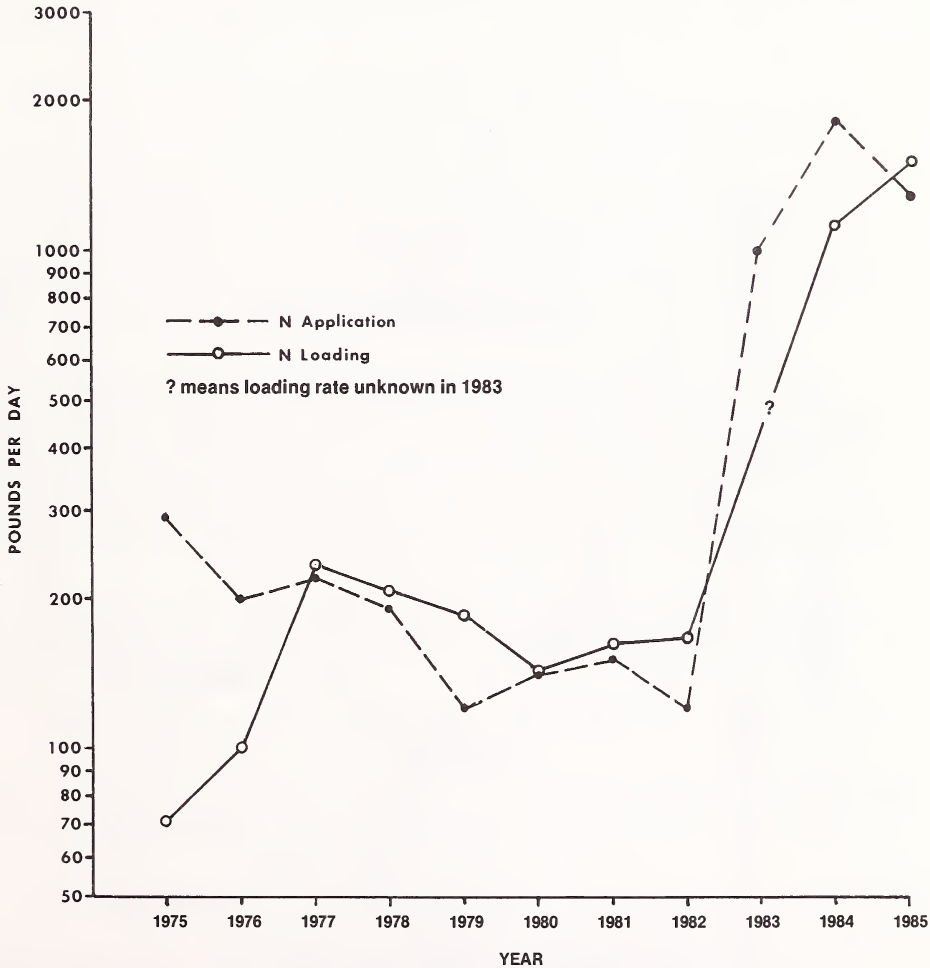
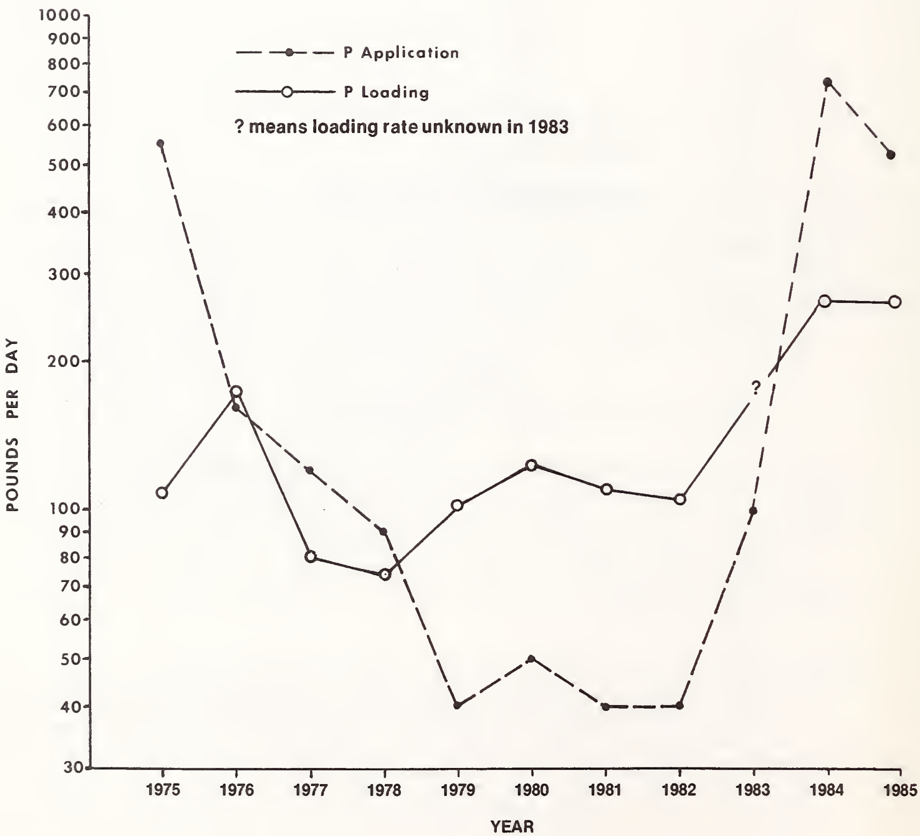


Figure 5. Phosphorus (P) application and loading rates at Champion International since 1975.



Weston (1985) reported that concentrations of soluble nutrients in the effluent from the aerated basins can be maintained below 5 mg/l nitrogen and 1 to 2 mg/l phosphorus without deleteriously affecting the performance of the biological treatment system. This amounts to 625 pounds per day of soluble nitrogen and 125 to 250 pounds per day of soluble phosphorus in the aerated basin effluent. To achieve these target levels and to minimize the application of nutrients, Weston recommends monitoring the quality of effluent from the aerated basins and adjusting application rates as necessary. This should reduce nutrient loading to the Clark Fork River below the rates measured in 1984-1985. Champion will be required to continue to monitor for nutrients, both in its wastewater discharges and in selected monitoring wells.

Nutrient Concentrations and Eutrophication Potential

Average nutrient concentrations in the Clark Fork were highest at Turah, at the upper end of the reach of river studied by the DHES in 1984 and 1985 (Figure 6). The major tributaries had, on the average, smaller concentrations of nutrients than the mainstem, thus serving to dilute ambient concentrations in the Clark Fork. The two major dischargers in this reach--the City of Missoula and Champion International--effectively "bumped" nutrient concentrations back up nearly to the levels recorded at Turah. Downstream from Huson, nutrient concentrations declined to the bottom end of the study reach below Noxon Dam.

Seasonally, nutrient concentrations tended to be largest during snowmelt runoff in spring and smallest in fall and winter. At the Huson station in July and August--the time of low flows, peak water temperatures and the maximum effect of algal respiration--nutrient concentrations averaged less than the annual averages plotted in Figure 6 and much less than those predicted in the Champion PER (Shewman et al. 1984). Concentrations at Huson and downstream should begin to decline in the near future as Champion reduces nutrient application rates.

The DHES, on recommendation from the U.S. EPA Region VIII (DHES, 1984), has adopted the following ambient nutrient concentration guidelines for assessing the potential for producing nuisance growths of attached algae in flowing waters:

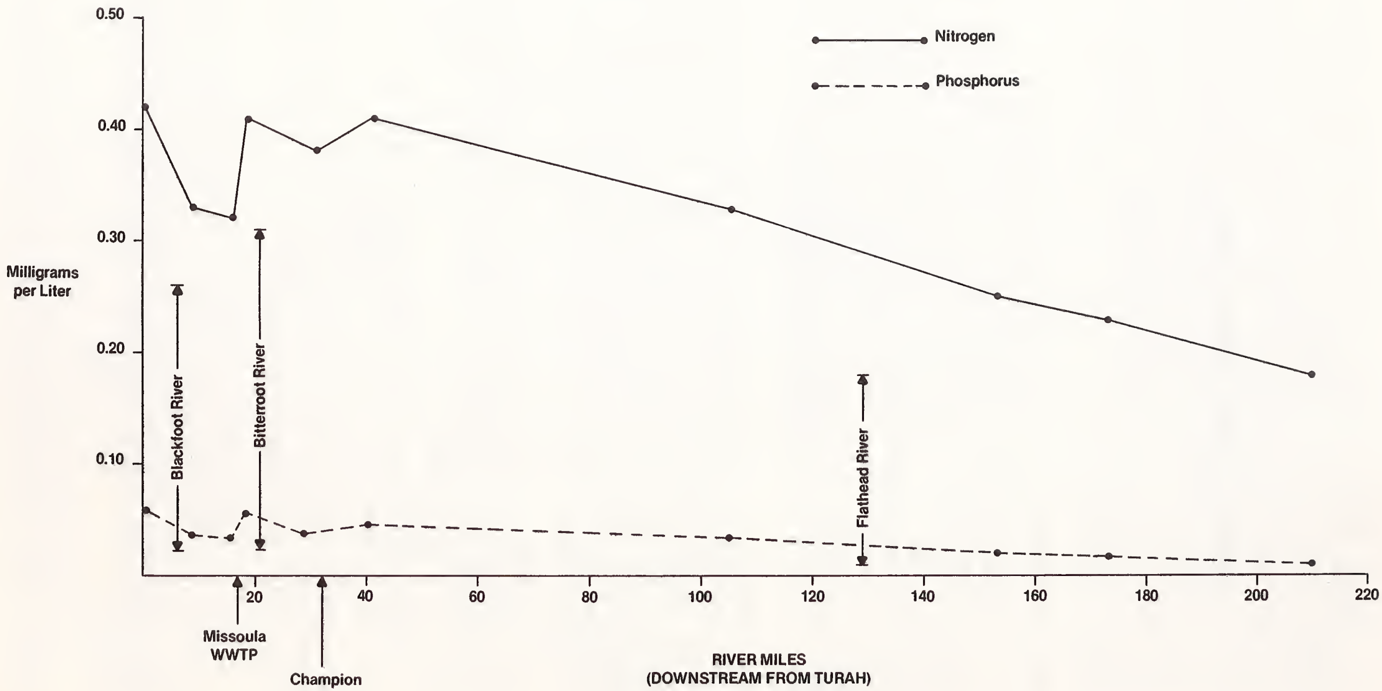
1.0 milligram per liter total inorganic nitrogen
0.1 milligram per liter total phosphorus

These guidelines are used in tandem. In other words, both the nitrogen and the phosphorus guideline must be exceeded at the same time if nuisance algae growths are likely to develop.

Average concentrations of TN and TP in the lower Clark Fork River (Figure 6) were all well below these guidelines. At Huson, the downstream end of the Champion mixing zone, only the TP guideline was exceeded, and that occurred once, on the sampling date corresponding to the peak of runoff in 1984. (The TP guideline was also exceeded at Harper Bridge on that date.)

For large rivers and run-of-the-river reservoirs where populations of suspended algae may develop, Mills et al. (1982) recommend a different set

Figure 6. Average concentrations of total nitrogen and total phosphorus in the Clark Fork River and tributaries, March 1984 through August 1985 (Number of samples = 25)



of nutrient guidelines for assessing eutrophication potential (Table 4). Pairs of TN and TP measurements in the Clark Fork River above Thompson Falls Reservoir exceeded the "problem threshold" guidelines on 9 of 25 sampling dates but did not exceed the "problem likely to exist" or "severe problems possible" guidelines on any date.

Table 4. Eutrophication potential in large rivers as a function of ambient nutrient concentrations (Mills et al. 1982) and the number of tandem exceedences above Thompson Falls Reservoir.

Significance	Phosphorus (mg-P/l)	Nitrogen (mg-N/l)	Number of Exceedences
Problem threshold	0.013	0.092	9
Problem likely to exist	0.13	0.92	0
Severe problems possible	1.3	9.2	0

Guidelines for algal biomass corresponding to these nutrient guidelines for large rivers are presented in Table 5. The guidelines in Tables 4 and 5 are based on empirical data for nutrients and algal biomass collected from a variety of rivers. Since rivers respond differently to nutrient additions, assessments of eutrophication potential based on nutrient concentrations alone should be done with caution.

Table 5. Eutrophication potential in large rivers as a function of dry algal biomass (Mills et al. 1982) compared to the range of suspended algal biomass measured in Clark Fork River reservoirs in 1984 and 1985.

Significance/Reservoir	Dry Algal Biomass (mg/1)
Problem threshold	1.45
Problem likely to exist	14.5
Severe problems possible	145.0
Milltown	0.116-0.555*
Thompson Falls	0.293-0.543*
Noxon Rapids	0.053-0.408*
Cabinet Gorge	0.117-0.296*

*Calculated from reservoir chlorophyll a concentrations (Data Report, Volume 1, Table 26) assuming chlorophyll a constitutes 1% of the dry weight of organic material in plankton algae (APHA et al. 1981, page 950).

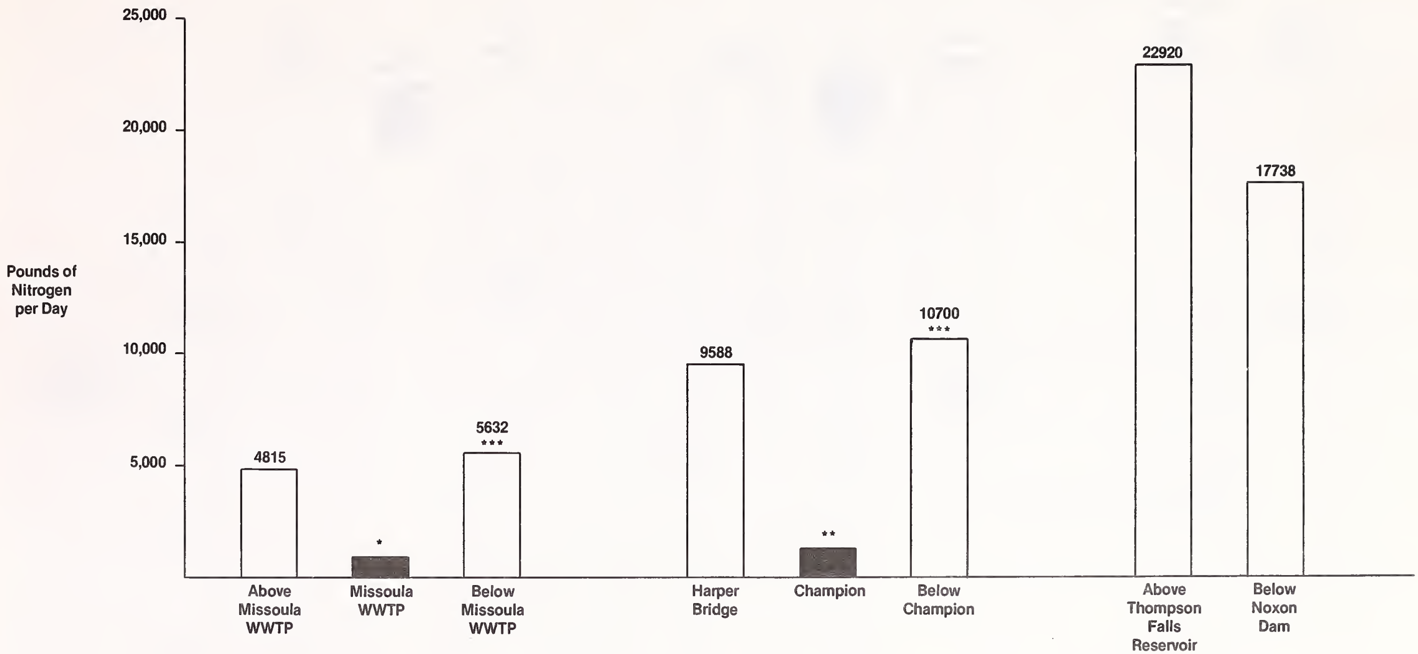
Comparison of reservoir algal biomass data with algal biomass guidelines for assessing eutrophication potential (Table 5) indicates that all of the algal biomass concentrations recorded by DHES fall below the "problem threshold." However, a localized bloom of blue-green algae (*Anabaena flos-aquae*) has been reported from Noxon Reservoir (Dr. Vicki Watson, Botany Department, University of Montana, personal communication).

Nutrient Loading and Lake Pend Oreille

Average daily nutrient loading rates from March 1984 through August 1985 are presented in Figures 7 and 8 for selected stations and permitted discharges along the lower Clark Fork River.

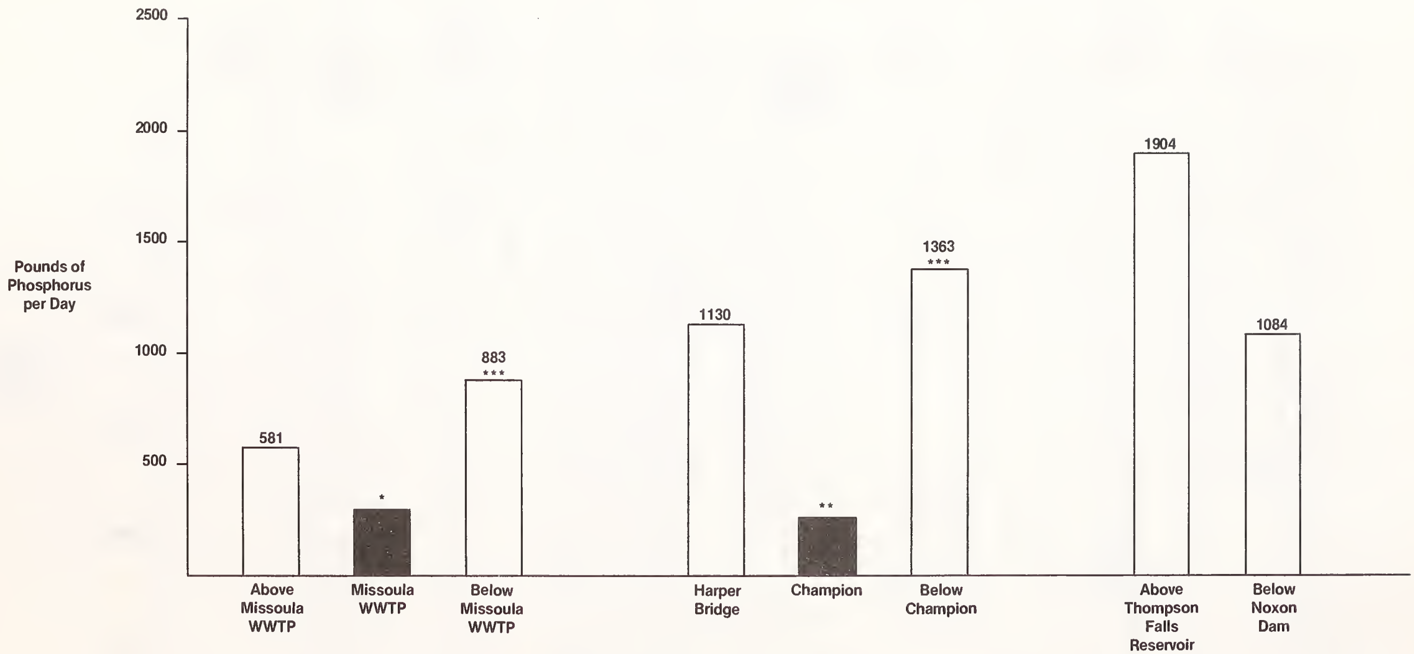
Nutrients in the City of Missoula effluent represented 16 percent of the nitrogen and 34 percent of the phosphorus that was present in the river below the wastewater treatment plant (WWTP). It appears that the Missoula WWTP discharged considerably more nitrogen and phosphorus in 1984 and 1985 than it did in 1981 or 1982 (Table 6).

Figure 7. Average daily nitrogen loads carried by the Clark Fork River at selected stations, March 1984 through August 1985.



* 900 lbs/day
** 1,333 lbs/day (270 lbs/day seepage; 1063 lbs/day direct discharge)
*** Predicted value based on instantaneous mixing and no instream attenuation

Figure 8. Average daily phosphorus loads carried by the Clark Fork River at selected stations, March 1984 through August 1985.



* 301 lbs/day
** 267 lbs/day (70 lbs/day seepage; 197 lbs/day direct discharge)
*** Predicted value based on instantaneous mixing and no instream attenuation

Table 6. Recent nutrient loading rates by the City of Missoula WWTP

Year	Average Daily Loading Rate (lbs/day) TN	TP
1981*	472	167
1982*	513	158
1984*	601	287
1984**	981	318
1985*	559	221
1985**	819	284

* Calculated from City of Missoula self-monitoring data
** Calculated from DHES monitoring data

Nutrients in the Champion discharge represented 12 percent of the nitrogen and 20 percent of the phosphorus that was present in the river below the mill. Approximately 23 percent of the nitrogen and 43 percent of the phosphorus load in the river above Thompson Falls is removed ("trapped") in Thompson Falls and Noxon reservoirs (Figures 7 and 8).

A large portion of the nutrients discharged by the Missoula WWTP and by Champion International will not reach the downstream reservoirs and Lake Pend Oreille in a form that is available to phytoplankton (suspended algae) or at the time of year (summer) when excess phytoplankton production is most critical. A study conducted on a 54-mile reach of eastern Washington's Spokane River in July, August and September of 1984 indicated that more than 40 percent of the influent load of TP was reduced instream (Patmont et al. 1985). This removal was due to biological uptake by attached plants (periphyton), chemical adsorption on the river bottom, and river seepage into the adjacent aquifer. A similarly intensive study would be needed to measure phosphorus attenuation in the Clark Fork along the 137-mile-long reach of river between the Missoula WWTP and Thompson Falls Reservoir.

Limited studies in 1984 and 1985 by the State of Idaho Department of Health and Welfare Division of Environment (IDHW-DOE) indicate that Lake Pend Oreille has generally retained its oligotrophic status except for localized algal blooms and patches of floating scum (IDHW-DOE Report to the Champion Technical Advisory Committee, January 18, 1985; IDHW-DOE unpublished data; M.A. Beckwith, IDHW-DOE, personal communication). In 1984 and 1985, water clarity (measured by Secchi Disc) and phosphorus concentrations in Lake Pend Oreille were virtually unchanged from the years before Champion was granted its current permit to discharge wastewater (Remarks by M.A. Beckwith, IDHW-DOE, to the Water Quality Management Conference held September 20, 1985 in Coeur D'Alene, Idaho). A much more intensive nutrient loading and limnological study, such as the one proposed by Woods and others (1985), is needed to assess the susceptibility of Lake Pend Oreille to cultural eutrophication from nutrients carried by the Clark Fork River and those originating elsewhere in the lake's watershed.

Summary

The Clark Fork River is primarily phosphorus-limited where it passes the Champion mill. The largest average concentrations of both nitrogen and phosphorus were found at Turah. Tributary flows from the Blackfoot, Bitterroot and Flathead rivers served to dilute nutrient concentrations in the Clark Fork; discharges from the City of Missoula WWTP and Champion served to elevate nutrient concentrations nearly to the levels recorded at Turah. Clark Fork nutrient concentrations declined steadily downstream from Huson to the lowest levels recorded below Noxon Dam.

Nutrient application and loading rates at Champion were at all time high levels during the DHES Clark Fork study. At the same time, nutrient loading rates by the Missoula WWTP were higher than the rates measured in 1981 and 1982. Champion has begun to reduce its nutrient application rates and expects to reduce them further.

Nutrient concentration guidelines for avoiding nuisance growths of attached algae were not exceeded during the study below the Missoula or Champion discharges. Nutrient concentration guidelines for avoiding blooms of suspended algae were exceeded in 36 percent of the samples collected above Thompson Falls Reservoir, but algal biomass measurements in the Clark Fork River reservoirs were all below the problem threshold.

A large portion of the nutrients discharged by the Missoula WWTP and Champion does not reach Lake Pend Oreille. A significant but unknown fraction is probably attenuated instream through assimilation by periphyton, chemical adsorption on the river bottom and river seepage into the adjacent aquifer. In addition, about 23 percent of the nitrogen and 43 percent of the phosphorus load in the river above Thompson Falls is trapped in Thompson Falls and Noxon reservoirs. Lake Pend Oreille has shown no overt signs of advancing eutrophication during the term of the current discharge permit.

Suspended Solids

Definition and Implications

The weathering of land and transportation of eroded material by water, wind and ice are natural processes that largely determine the characteristics of land, rivers, estuaries and lakes. However, man has greatly increased the rates at which sediments are delivered to streams by accelerating erosion through various land use practices or through the direct discharge of solid materials to waterways.

Suspended solids in streams include both inorganic and organic material. Inorganic components include sand, silt and clay. Organic matter may be composed of a variety of material originating from natural and man-made sources.

The concentrations and makeup of suspended particles in surface waters are important for a variety of reasons. The most obvious is aesthetics.

Increasing concentrations of sediments in rivers and streams degrades the appearance of the water and thereby reduces recreational potential and

aesthetic enjoyment. Less obvious effects of sedimentation are a reduction in light penetration (and hence the amount of sunlight available to aquatic plants), increased stream temperatures (due to absorption of solar energy by sediment particles) and numerous potential impacts on various forms of aquatic life. Sediments may clog the gills of fish and invertebrate organisms, smother developing eggs and reduce the availability of food. If sediment particles include substantial quantities of organic matter and settle to the bottom, anaerobic conditions can occur with resulting decreases in dissolved oxygen and pH levels. This has been a special concern in the Clark Fork where a reduced pH could solubilize toxic heavy metals in bottom sediments. Other, considerations are that sediment particles may adsorb toxic materials or release undesirable dissolved products into the water.

Background Levels of Suspended Solids in the Clark Fork River.

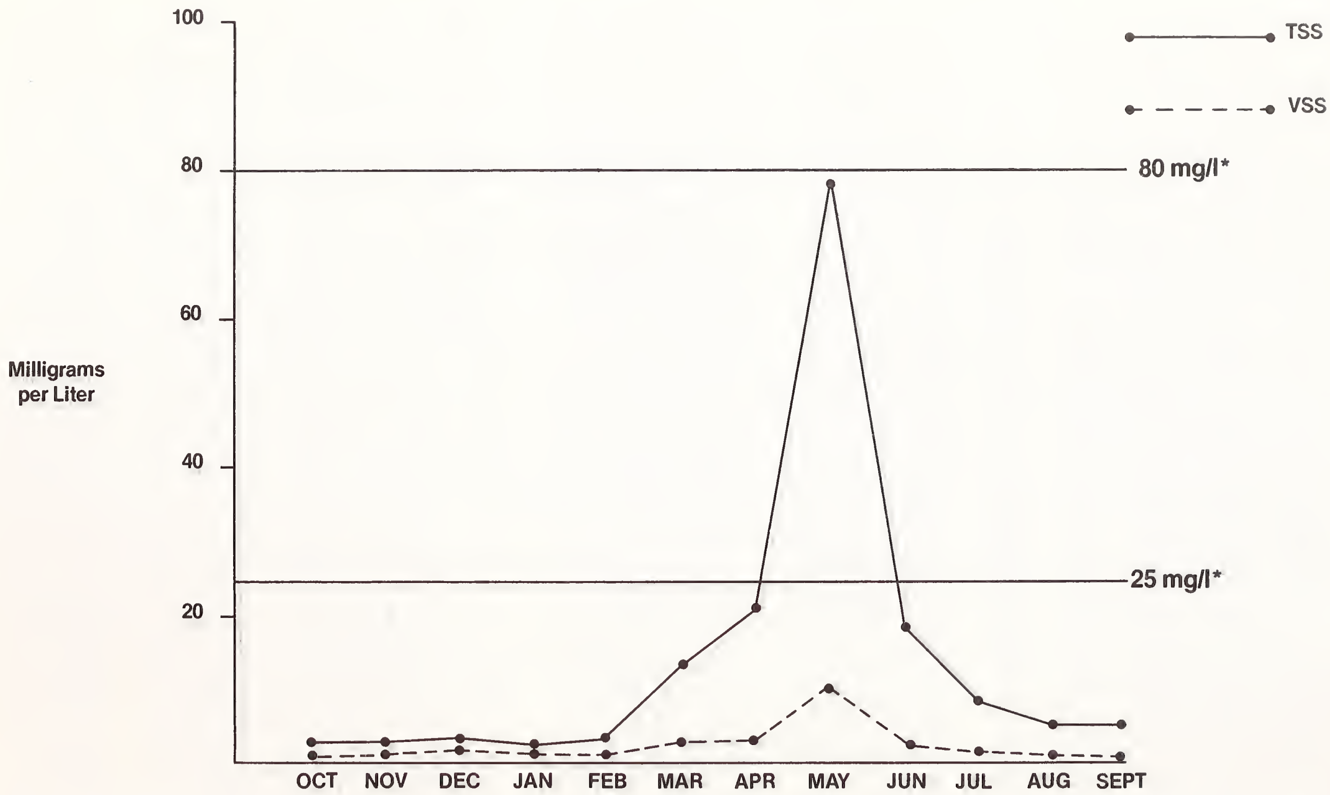
During the 1984-1985 water quality study of the Clark Fork River, the concentrations of both the organic and inorganic suspended solids were routinely determined. TSS refers to the weight per unit volume of the total quantity of suspended solids, organic and inorganic, measured in a given river sample. Volatile suspended solids (VSS) is the weight per unit volume of the organic sediment in the same sample. Thus, to determine the inorganic component, one merely subtracts the weight of the organic fraction (VSS) from the weight of the TSS.

The Clark Fork River from Missoula to the Idaho border can be characterized as appearing clear year around except for a brief period during spring runoff. There is little doubt that the river today carries higher average concentrations of TSS than, say 200 years ago due to the effects of historic mining activities upstream, agricultural and timber harvesting and channelization of the river for highway and railroad construction. However, TSS concentrations are probably less today than 50 or even 25 years ago when excessive amounts of untreated mining and municipal wastes reached the river.

Figure 9 shows the concentrations of TSS and VSS in the Clark Fork River at Harper Bridge over the course of a water year (October-September). The data are monthly averages of one to five observations using a total of 25 measurements taken between March 1984 and August 1985. The European Inland Fisheries Advisory Commission (1965 in National Academy of Science (NAS), 1973) states that "...there is no evidence that concentrations of suspended solids less than 25 mg/l have any harmful effects on fisheries; it should usually be possible to maintain good or moderate fisheries in waters that normally contain 25 to 80 mg/l suspended solids, other factors being equal, however, the yield of fish from such waters might be somewhat lower than from those in the preceding category." Thus, from the standpoint of these criteria, the Clark Fork at Harper Bridge would fall in a good or excellent category for 10 months out of the year and be in the good to moderate range during the months of April and May. The graph also points out that the organic fraction of the TSS is consistently small.

Data for other Clark Fork monitoring stations between Missoula and the Flathead River confluence are comparable to Figure 9 although the average May concentrations tend to be slightly higher. The Blackfoot, Bitterroot

Figure 9. Average monthly concentrations of TSS and VSS in the Clark Fork River at Harper Bridge, March 1984 to August 1985. (Number of samples = 25)



* 25 mg/l — good fisheries
25-80 mg/l — good to moderate fisheries
(EIFAC (1965) in NAS (1973))

and Flathead Rivers and the Clark Fork below the Flathead all tend to carry lower monthly average TSS concentrations year around.

Figure 10 is a graph showing the average annual concentrations of TSS and VSS in the Clark Fork River and its tributaries for 1984-1985 by stream mile. These data are means of 12 monthly average concentrations like those used in Figure 9, and are useful for examining downstream trends. The general trend is one of decreasing TSS and, to a lesser extent, VSS concentrations with increasing distance downstream from Turah (mile 0.00). The exception is the marked increase from Harper Bridge (mile 28.5) to Huson (mile 40.5). Possible explanations for this trend and the effects of Champion's wastewater discharge will be examined later in this section.

Initial decreases below Turah are due to dilution of the TSS concentration by the cleaner Blackfoot and Bitterroot Rivers. Further downstream, the Flathead contributes additional dilution. The relatively small volume Thompson Falls Reservoir at mile 169 seems to act as a settling basin for some of the TSS. The huge amount of TSS settling out in the Noxon Rapids Reservoir at mile 198 is particularly striking. The remaining TSS entering Cabinet Gorge Reservoir at mile 224 are apparently too small and light for further settling to occur. Thus, in the 230 mile reach of river from Turah to the Idaho border, the average total suspended solids concentration was reduced nearly 14-fold due to dilution by cleaner water tributaries and settling of solids in the impoundments. The reduction of organic solids was less significant--nearly four-fold.

Suspended solids added to a river are capable of having cumulative as well as instantaneous effects on water uses. Thus, it is meaningful to examine the load of suspended solids (in pounds or tons of solids per unit of time) carried by a river and the discharges to it, in addition to the concentration of solids.

When discussing the concentrations and loading of suspended solids, it is well to consider that the key to the relationship is the volume of water in the stream. As the Clark Fork flows downstream and is joined by tributaries, it's volume becomes progressively greater. The tributaries contribute pounds or tons of suspended solids, but the tributaries also have fewer milligrams per liter of suspended material, thus even though the tributaries are adding more material (loading), they are also diluting the concentration of the Clark Fork as it flows towards Idaho.

Figures 11 and 12 show the average daily TSS and VSS loads carried by the Clark Fork and its tributaries from above the Missoula WWTP to the Idaho border. Since each tributary stream, no matter how pure, carries a certain amount of suspended solids, loads tend to be additive as the tributaries flow into the main river. Deposition and resuspension of sediments may occur throughout any given reach of stream and the banks themselves may contribute significantly to the suspended solids load of the stream. As a result the total load may not always increase smoothly in a downstream manner, but usually fluctuates somewhat, with the general trend being a downstream increase.

The figures indicate a generally gradual downstream increase in both TSS and VSS loads. Rather major increases are noted below the Bitterroot

Figure 10. Average annual concentrations of TSS and VSS in the Clark Fork River and tributaries, March 1984 through August 1985. (Number of samples = 25)

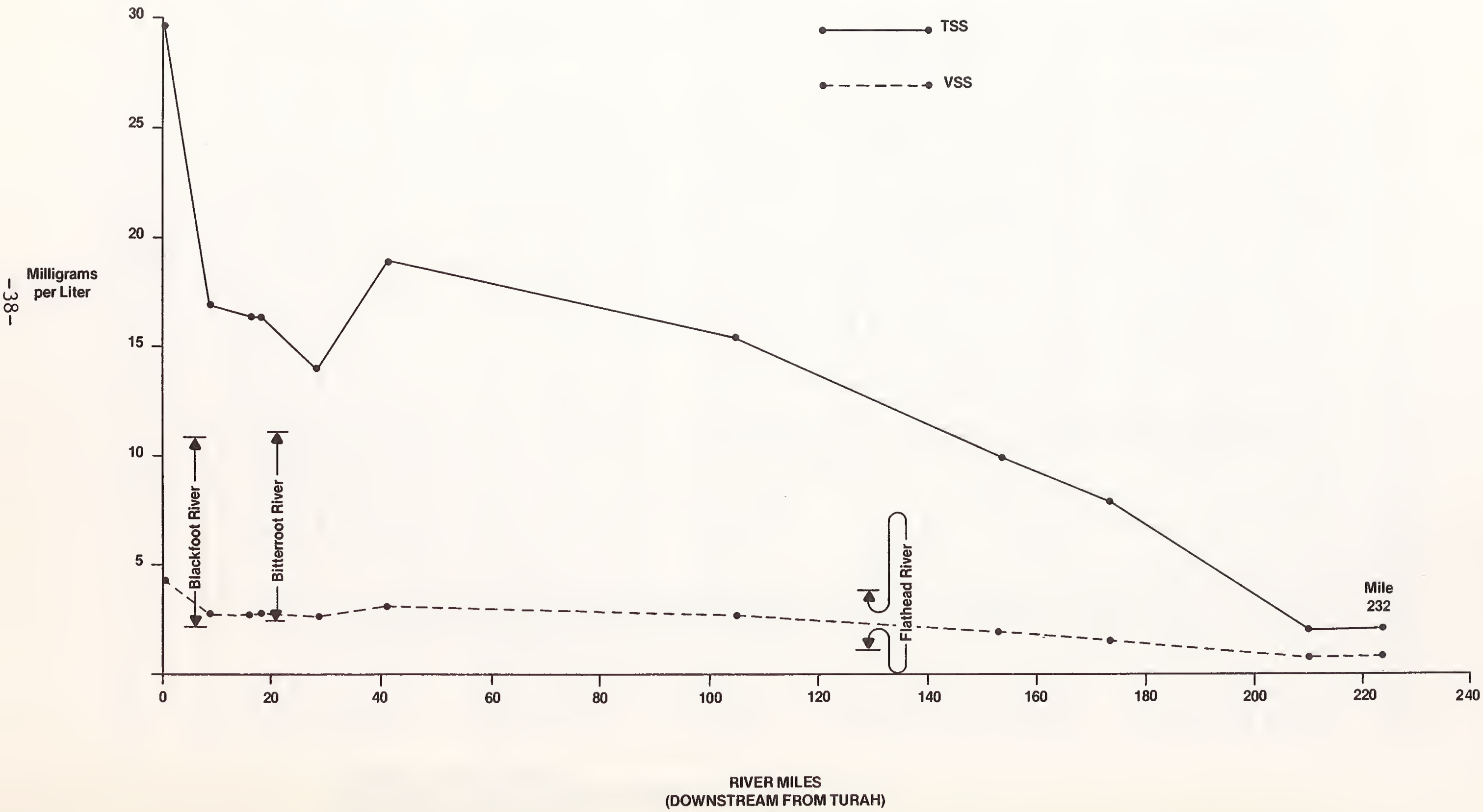


Figure 11. Average daily TSS loads carried by the Clark Fork River and tributaries, March 1984 through August 1985.

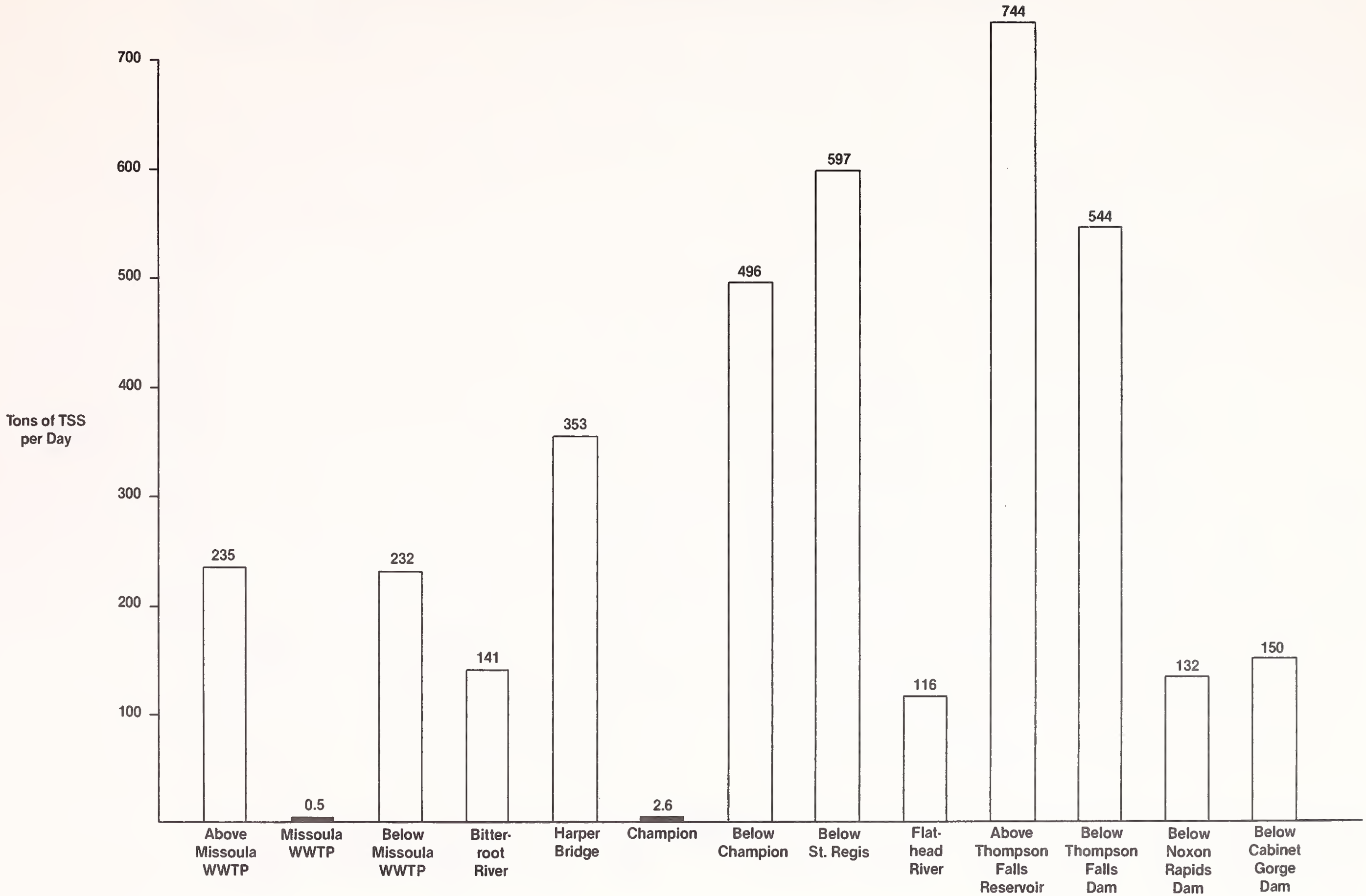


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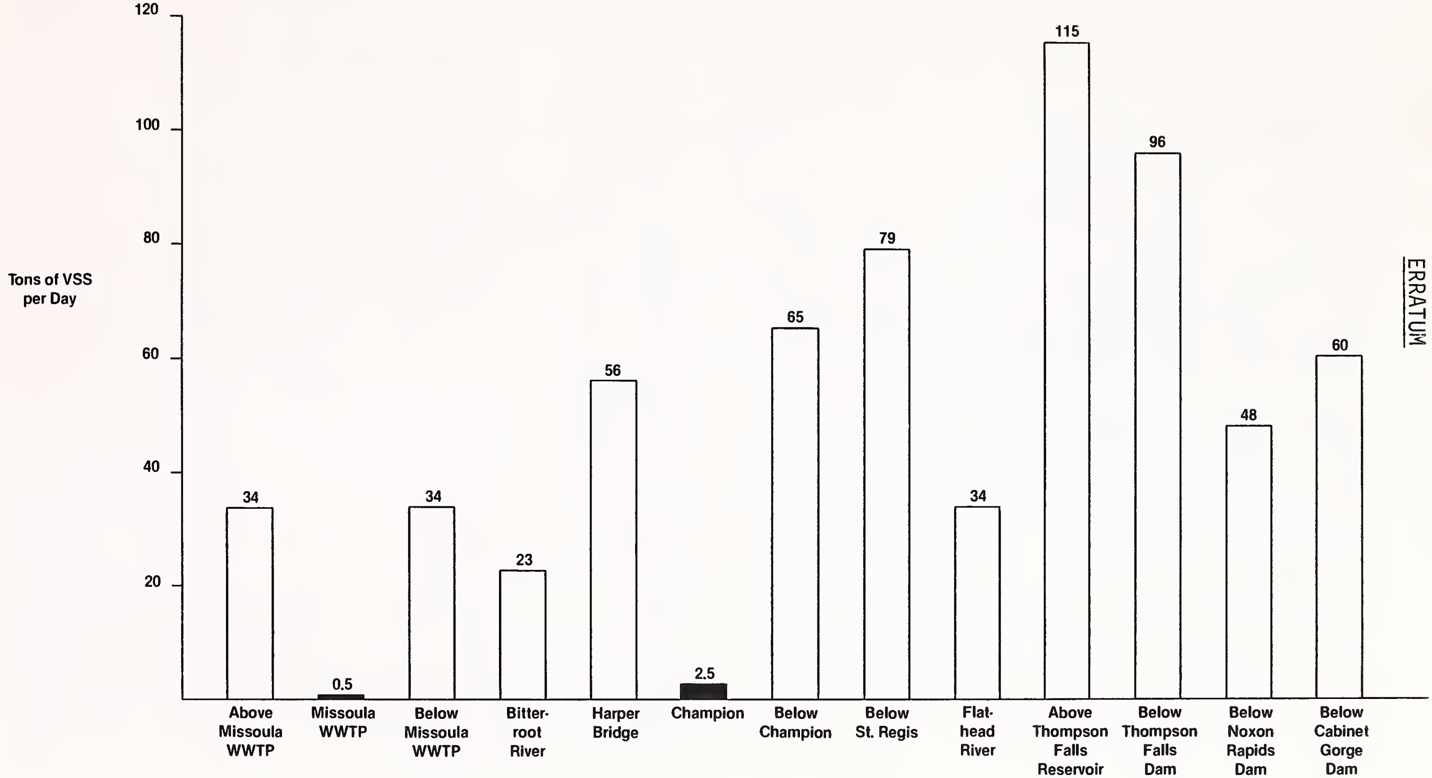
Figure 12. Average daily VSS loads carried by the Clark Fork River and tributaries, March 1984 through August 1985.



and Flathead Rivers as these major tributaries discharge their sediment loads to the Clark Fork. TSS also increases markedly from above to below Champion; VSS shows a much less significant jump. Peak loads of both TSS and VSS in the lower Clark Fork were present at the monitoring station above Thompson Falls Reservoir. Downstream from this point, the load fell off markedly (especially below Noxon Rapids Reservoir) as it was deposited in the series of impoundments. Cabinet Gorge Reservoir has no apparent effect; the suspended material leaving Noxon Rapids Reservoir is probably very fine clay particles and living reservoir organisms that are not conducive to further settling. Despite a greater than six-fold increase in total volume of flow from above the Missoula WWTP down to below Cabinet Gorge Dam, the total suspended solids load actually declined by about 36 percent (and to only 25 percent of its peak above Thompson Falls Reservoir) as a result of the lower Clark Fork impoundments.

Effects of the City of Missoula Wastewater Treatment Plant (WWTP) and Champion Discharges

As Figures 9 and 10 illustrated, the concentration of suspended organic material (VSS) in the Clark Fork River is very small when compared to the total suspended solids levels, averaging from about 13 to 19 percent of the total at any given station down to the reservoir system. Below Noxon Rapids and Cabinet Gorge Dams, the figure jumps to around 38 percent when the inorganic fraction has largely settled out and the remaining solids consist of a high proportion of organic material, presumably living reservoir organisms (plankton).

Below Missoula, two major point sources, the City of Missoula WWTP and the Champion Frenchtown Mill, discharge wastewaters to the Clark Fork that contain relatively high concentrations of organic suspended solids. The effects each of these discharges has on the concentrations and total loads of VSS in the Clark Fork will be examined separately.

Missoula WWTP

The Missoula WWTP continuously discharges an average of about 8.86 cfs of secondary treated wastewater to the Clark Fork just downstream from the Reserve Street Bridge. Concentrations of TSS in the effluent are variable, but average about 21.2 mg/l, of which about 19.8 mg/l (93 percent) is organic matter. The concentration of solids in the effluent at any given time is determined by the efficiency of the treatment process and the seasonal and daily variations in influent flow. Several instances of operational problems at the plant during the 18 months of study caused TSS concentrations to greatly exceed the average for relatively brief periods.

Since suspended solids in the WWTP effluent are largely organic, this assessment will examine only VSS. Given the average effluent flow rate of 8.86 cfs and a VSS concentration of 19.8 mg/l, the WWTP discharges about 946 pounds, or just less than a half ton of organic solids to the Clark Fork every day.

The Clark Fork above the WWTP discharge carried an average organic solids concentration of 2.8 mg/l and a load of 68,267 lbs/day (34.1 tons/day) in 1984-1985. If none of the VSS settled out or was consumed by aquatic organisms (in fact the organic solids act as a food source for

aquatic insects) the WWTP discharge would increase the average concentration and load in the Clark Fork by about 1.4 percent. Data for a monitoring station located on the Clark Fork two miles below the WWTP discharge shows an average VSS concentration of 2.9 mg/l and a load of 68,886 lbs/day (34.4 tons/day) or not far from anticipated levels. Given the precision of the VSS test (See Appendix B, Data Report, Vol. 1), it appears, on the average, the Missoula WWTP does not contribute measurably to the background concentration or load of VSS in the Clark Fork.

Worst Case Scenario

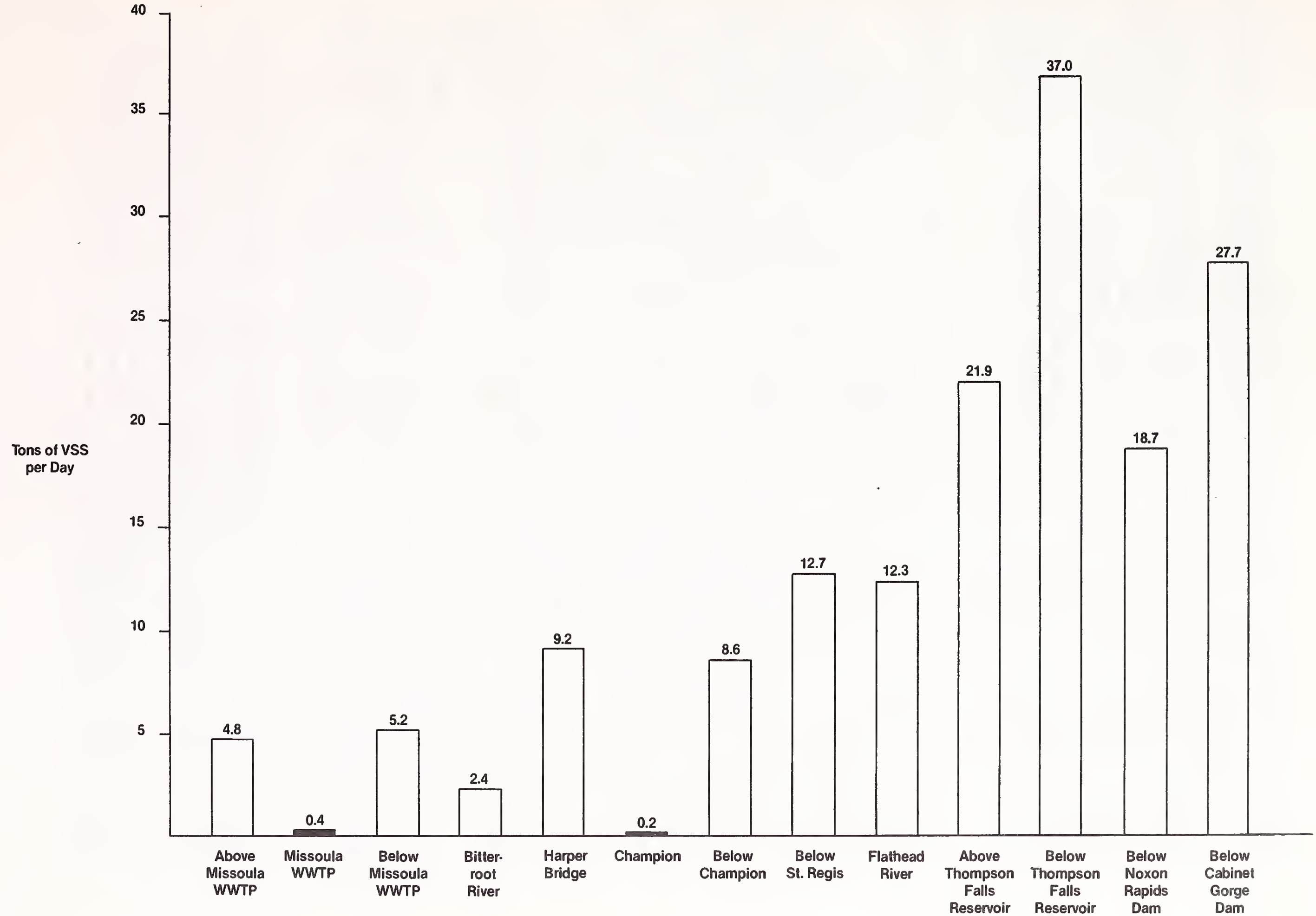
Because the Missoula WWTP discharges wastewater at a relatively constant rate, the maximum impact of organic solids to the river would occur during periods of low flow due to low dilution rates. The lowest flows in the Clark Fork typically occur in winter. However, it is assumed the treatment plant's VSS would exhibit its greatest affect on aquatic life during summer low flow periods. This is due to dissolved oxygen being at its seasonal low and river temperature at its peak. The combination results in a condition of stress for cold water aquatic life. Discharged organic solids consume oxygen in the river as they decompose, further contributing to the natural seasonal decline in dissolved oxygen.

Lowest summer flows in the Clark Fork usually occur in August. Peak stream temperatures frequently take place in that month as well. During August of 1984 and 1985, the Clark Fork above the WWTP carried an average VSS concentration of 1.2 mg/l and a load of 9,540 lbs/day (4.8 tons/day). The WWTP discharged VSS at 17.4 mg/l and 844 lbs/day (0.4 tons/day). Thus, in this worst case scenario, the approximate increase in VSS concentration and load from the WWTP discharge would be 8.8 percent more than the background average. The data for the monitoring station two miles below the WWTP showed an average August VSS concentration of 1.3 mg/l and a load of 10,335 lbs/day (5.2 tons/day) or an 8.3 percent increase over average background levels. While this measured increase is much more significant than the annual average increase, and is very comparable to the theoretical increase, the background instream VSS concentrations are very low. As such, the theoretical percentage increase, although, numerically large, results in instream levels which are still very low. The measured increase from 1.2 to 1.3 mg/l is beyond the precision of the test and cannot be considered meaningful. As such, effects on river chemistry and biota are highly unlikely. The average daily VSS loads carried by the Clark Fork and tributaries in August 1984-1985 are shown in the histograms in Figure 13.

Champion Frenchtown Mill

Under its current discharge permit, the Frenchtown Mill discharges an average of 9.1 cfs of secondary treated effluent directly into the Clark Fork River, downstream from Harper Bridge. Additional wastewater reaches the river via seepage from storage ponds and rapid infiltration basins. Concentrations of TSS in the effluent are variable but average about 95 mg/l (1984-1985 data), of which about 91 mg/l (95 percent) is organic matter. The concentration of solids in the effluent at any given time is primarily a function of retention time in the pond system. A minimum of 10 days retention is required prior to discharge, although longer term storage frequently occurs when influent flows exceed effluent flows due to permit limitations governing the rate of discharge to the Clark Fork. All of the

Figure 13. Average daily VSS loads carried by the Clark Fork River and tributaries in August, 1984- 1985.



TSS in the seepage are removed by percolation before it reaches the river, thus, there should be no contribution of VSS to the river via seepage.

Discharge rates vary seasonally due to discharge permit limitations governing allowable color in the river, river dissolved oxygen and other parameters. TSS loading rates are typically highest in the spring (average for May 1984-1985 of 24,149 lbs/day) and lowest in winter (average for January 1984-1985 of 274 lbs/day). The annual average was about 5,265 lbs/day (2.6 tons/day) or more than 5 times that contributed by the Missoula WWTP. In 1984-1985, the Champion mill discharged an average of 1.92 million pounds of TSS to the Clark Fork over the course of the year. Of these totals, 1.63 million pounds, or 85 percent, was discharged during the months of April through July.

As with the Missoula WWTP, the TSS in Champion's effluent are largely VSS (see Aesthetics Section for makeup of Champion solids). The following analysis concentrates on the organic component or VSS contributed by Champion discharge in the surface discharge. The Clark Fork at Harper Bridge (above the Champion discharge) carried an average organic solids concentration of 2.7 mg/l and a load of 112,397 lbs/day (56.2 tons/day) in 1984-1985. If none of the VSS settled out or was consumed by organisms prior to mixing, the increase in VSS concentration and load would be about 4.5 percent in the Clark Fork below the Champion discharge. Data for the monitoring station Clark Fork at Huson, however, show an average 15 percent increase in VSS concentration and a 16 percent increase in VSS load when compared to the Harper Bridge station. Several possibilities exist that would explain the discrepancy. The first, and least likely is that the Harper Bridge monitoring station produced data which was not representative of the river in that reach, hence, suspended solid levels were underestimated. During the early part of the water quality study, the trend emerged of significantly increased TSS and VSS concentrations at Huson above what the Champion discharge could be contributing. To verify that Harper Bridge data were representative, validation studies were conducted. Studies revealed that the station and the data generated were representative.

A second explanation involves the theory that dilution of the Clark Fork's suspended solids concentration by the cleaner Bitterroot River results in an increased sediment carrying capacity and erosive potential. The so called "hungry water" begins to scour the streambanks and bed in the reach below the Bitterroot and reaches a peak suspended solids concentration in the vicinity of Huson before tapering off.

A third theory alluded to in reports by Kicklighter and Stanford (1985) and Ekisola (1985) is that dissolved organic matter in the seepage from Champion may undergo flocculation or precipitation in the river, thereby causing an increase in particulate organic matter (or VSS) above that contributed by the direct discharge. While this seems possible, the average increase in VSS concentration between Harper Bridge and Huson was accompanied by an even more significant increase in TSS concentration and load (35 and 40 percent respectively). Therefore, it would appear that a very significant inorganic sediment source exists between the two monitoring stations, a fourth explanation.

Field observations made during the course of the study seem to confirm this last possibility--that of accelerated natural erosion of the stream banks and/or bed--as the most likely. The second explanation is probably a contributing factor. The stream reach from Frenchtown to Huson contains numerous actively eroding vertical banks. In several locations the channel seems to be actively moving, especially in the vicinity of the Huson railroad bridge. Such erosion would also tend to increase the VSS concentration of the river at Huson as algae was scoured from the river bed and terrestrial organic matter was contributed when river banks sloughed. An examination of the data shows that the percentage of organic matter in the total suspended solids is actually less at Huson (16.4) than at Harper Bridge (19.3). Therefore, it is unlikely that the Champion discharge is responsible for more than the theoretical 4.5 percent increase of the observed average 15-16 percent increase in VSS in the Clark Fork.

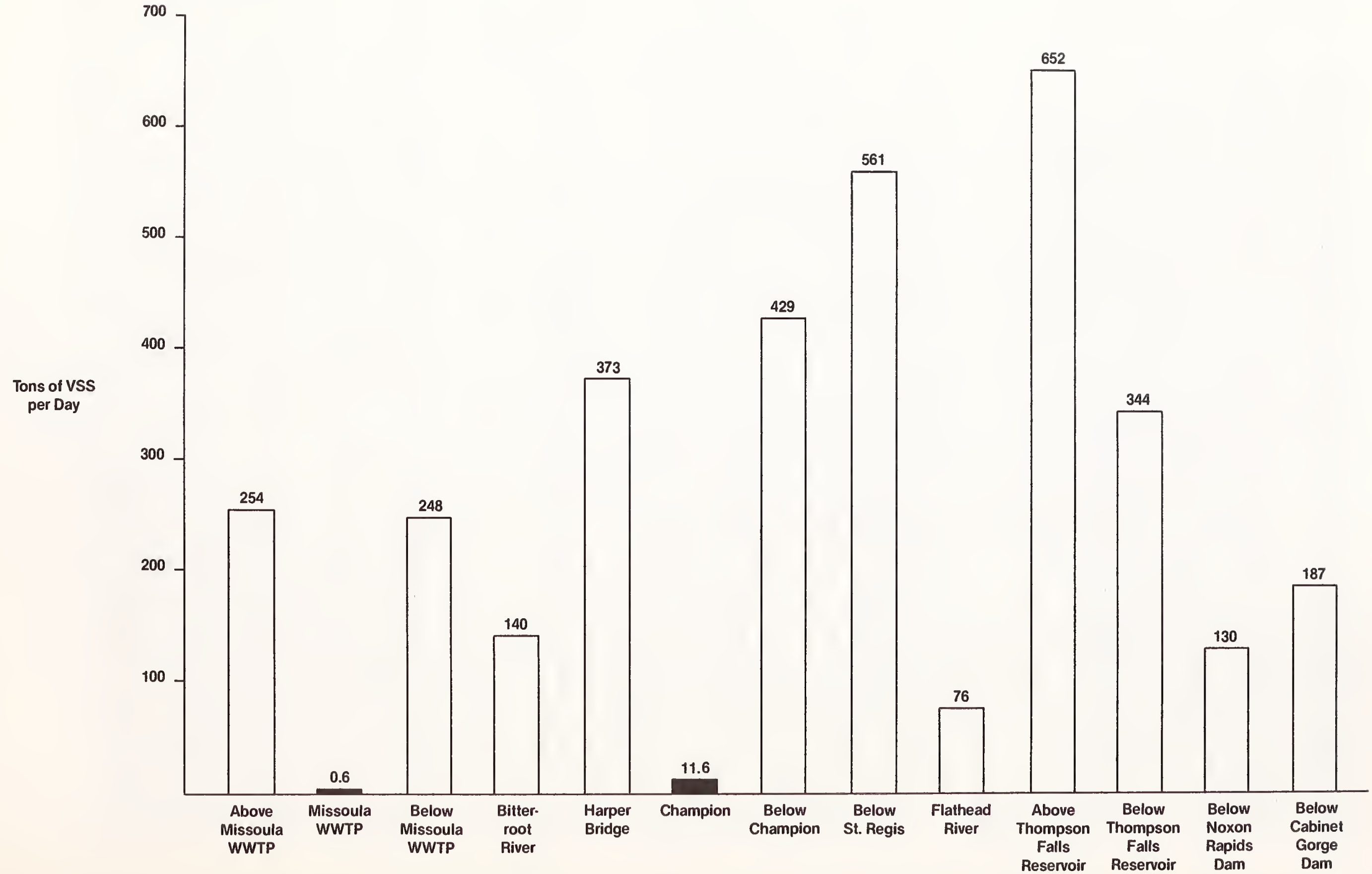
Worst Case Scenario

The dilution of Champion wastewater by river water is typically lowest during spring runoff due to high effluent discharge rates allowed by relatively little color contribution from seepage and greater amounts of river dissolved oxygen. Loading rates for wastewater VSS are highest during these times, but the background load carried by the river is also at its annual peak. During May in 1984 and 1985, Champion discharged an average of 23,173 lbs/day (11.6 tons/day) of VSS at an average flow rate of 39.4 cfs. The resulting dilution ratio of river water to wastewater was 331:1. The background load in the Clark Fork at Harper Bridge was 745,884 lbs/day (373 tons/day) at a flow rate of 13,055 cfs. Based on the sampling information, an anticipated increase in river VSS load and concentration of about three percent could be expected during an average spring high discharge period.

River monitoring data showed an average 15 percent increase in VSS at Huson for the month of May. Again, the influence of an additional suspended solids source is apparent. The TSS data showed nearly a 38 percent increase from above to below Champion for the same month. The average daily VSS loads carried by the Clark Fork and tributaries in May of 1984 and 1985 are presented in Figure 14.

During the high temperature, low flow periods of summer, the organic solids in Champion's discharge are diluted to a greater degree. Nonetheless, they are likely to have the greatest impact on the river biota at this time for the same reasons given in the Missoula WWTP discussion--low concentrations of dissolved oxygen and high temperatures. During August of 1984 and 1985, Champion directly discharged an averaged 1.87 cfs of wastewater, which contributed 417 lbs/day (0.2 tons/day) of VSS to the Clark Fork. The flow and VSS load at Harper Bridge averaged 2,452 cfs and 18,503 lbs/day (9.2 tons/day). The dilution ratio exceeded 1300:1. The expected increase in VSS load and concentration downstream should be about two percent. In fact, a slight decrease in VSS load and concentration was measured at Huson (from 9.2 to 8.6 tons/day and from 1.4 to 1.3 mg/l), although it cannot be considered significant due to the precision of the VSS test. These data are presented graphically in Figure 13.

Figure 14. Average daily VSS loads carried by the Clark Fork River and tributaries in May, 1984-1985.



Documentation of Impacts of Point Source Discharges

The general implications of TSS pollution in streams has been briefly discussed. In the Clark Fork system, concern by the public and the DHES regarding the discharge of organic solids by Champion and the City of Missoula WWTP centered around three possible instream impacts: 1) That organic solids could settle on the stream bed and physically interfere with the biota; 2) that organic solids could cause short or long-term toxicity, and 3) that increased TSS could reduce the concentration of dissolved oxygen. Additionally, there has been considerable concern that the latter category could result in depressed pH in river pools and the impoundments and that potentially toxic heavy metals contained in bottom sediments could be solubilized and thereby become biologically active. Various aspects of the Clark Fork River study examined the likelihood for each of the above impacts. It was shown earlier in this section that suspended solids loading by the Champion mill far exceeds that of the Missoula WWTP, and thus, has a much greater potential for causing impacts in the river. As such, the effects of the Champion discharge were the focus of the DHES' studies.

Eighty-five to ninety percent of the TSS in kraft mill effluents are bacteria or bacterial fragments (National Council of the Paper Industry for Air and Stream Improvement (ncasi) 1978A, 1978B, 1978C). Numerous microscopic examinations of Champion effluent performed in 1984 and 1985 confirm this. (See Data Report, Volume II, Aesthetics Monitoring). The solids were largely common non-pathogenic bacteria, with lesser quantities of fungi and algae. Wood fibers were never identified. Since these particles are very small and form colloidal suspensions (ncasi, 1978B), many of them remain in suspension indefinitely, even in still waters.

The river pool and reservoir bottom sediment sampling program conducted in 1984 by the DHES included analysis for the percent of organic matter in the bottom materials collected. These data (Data Report, Volume I, Deep-water Monitoring Section) indicate a lack of significant accumulations of organic sediment in the nine river pools and three impoundments examined downstream from the Champion discharge. In fact, field personnel had great difficulty in obtaining any kind of sediments in the river pools. The material most frequently encountered was clean gravel and rock. River pool bottom materials averaged 0.36 percent organic matter by weight in 25 samples, while the three lower impoundments averaged 1.26 percent in 19 samples, indicating that those bottom sediments were largely inorganic.

On the other hand, Ekisola (1985) documents subtle, but significant, increases in the rates of instream sedimentation of the 25 micrometer-150 micrometer fraction of fine particulate organic matter (FPOM) downstream from Champion using sediment traps buried in the river substrate. Although he concluded the organic solids in the Champion wastewater fell largely into the 25-150 micrometer size category, the FPOM collected in traps upstream of the discharge also consisted primarily of that size fraction of particles. (This is also the size range for many of the common single-celled algae that live in the Clark Fork.) Thus, from Ekisola's findings, a definite connection cannot be made between the increased sedimentation rate and the Champion discharge. Without ruling out the possibility of the Champion discharge contributing to Ekisola's findings, it seems likely that the documented 15-16 percent increase in instream VSS from above to below Champion could have contributed, at least partially, to

the slight instream increase in sedimentation rates. In summary, evidence has not proven that appreciable settling of organic solids contributed by Champion is occurring on the streambed or at the bottoms of river pools or the impoundments. The assessment of the structure of river-bottom macroinvertebrate communities above and below Champion provides further evidence for this conclusion.

The question of short or long term toxicity associated with the discharge of suspended solids by Champion can be divided into two parts: 1) Are the suspended solids capable of having a direct toxic effect on river biota, either through chemical or physical action or 2) do the solids contribute indirectly to a toxic condition in the river, either by causing a reduction in river dissolved oxygen or through pH effects which result in increases to the concentrations of toxic heavy metals?

The first question is best addressed by examining the result of the chronic Ceriodaphnia (water flea) and larval rainbow trout bioassays discussed in the Toxics Section. To summarize the results, no acute or chronic effects were documented. The second question can be addressed with the results of top and bottom water sampling conducted in the river pools and impoundments and through the examination of daily or diurnal dissolved oxygen survey results. The top and bottom water sampling included analyses for a host of dissolved heavy metals, dissolved oxygen concentrations, pH and many other variables. The data clearly indicate that pH, dissolved oxygen and dissolved metals values were generally similar at the tops and bottoms of the pools and impoundments. Slightly depressed dissolved oxygen levels were recorded twice in mid-summer at the bottoms of Noxon Rapids and Cabinet Gorge Reservoirs, but dissolved metals values did not increase appreciably, nor even approach toxic levels. The slight dissolved oxygen depressions were possibly due to a partial stratification of the impoundments.

The diurnal dissolved oxygen survey results and other river oxygen data are also discussed elsewhere and to summarize, those data conclude that the Champion wastewater discharge does not cause a depression in river dissolved oxygen below the state standard of 7.0 mg/l. As such, there should not be an indirect toxic effect of the Champion suspended solids discharge due to oxygen depletion.

Effects of the Proposed Action

Champion has requested to renew its current discharge permit for a period of five years. The permit now specifies an annual total suspended solids limit of four million pounds with mean monthly and daily maximum concentrations not to exceed 162 and 312 mg/l, respectively. However, Champion only discharged an average of 1.9 million pounds of TSS in 1984-1985. According to the management staff at Champion, there is always a possibility that conditions will arise in the future that will necessitate discharging to the full extent of the permit limits. Thus, in order to fully evaluate the effects of the proposed action, The DHES must predict the instream consequences of essentially doubling the TSS loading rates which occurred in 1984-1985.

Mean monthly stream flows for the Clark Fork at Harper Bridge above Champion were slightly higher than the long term average in Water Year 1984

and slightly lower than average in 1985, with the exception of June and July. The average flows for those months were from 30 to 50 percent of normal. Thus, average monthly stream flows computed from the 1984-1985 data should approach or be slightly less than long term average monthly flows for this station. These flow figures and the associated 1984-1985 suspended solids data were used in predicting the effects of doubling TSS loading.

Table 7 shows the mean monthly tons of background TSS and VSS in the river, and the additional load which would be contributed by the Champion if it discharged to its maximum permit limits for one year. The formula used to calculate the allowable discharge is as follows:

$$Qd = (1/Cd)(5Qr - 0.1855\ Sc)$$

where Qd = allowable discharge flow in cfs
Cd = discharge color in standard color units (SCU)
Qr = Clark Fork River flow in cfs
Sc = color (in lb/day) contributed to the river from pond seepage and rapid infiltration and
0.1855 = the conversion factor to convert lb/day into cfs-SCU.

The formula assumes a linear dilution of color in the river, imposes the five SCU (increase) instream color standard and makes an allowance for the contribution to river color from seepage by subtracting that amount from the allowable five units by dilution. For the purposes of these calculations, we have assumed 1000 SCU color in the discharge and that the TSS is 95 percent VSS.

The 1984-1985 data indicated that the yearly TSS and VSS loads below Cabinet Gorge Dam were on the order of 55,000 and 22,000 tons, respectively. A maximum yearly TSS and VSS discharge of 2,000 and 1,900 tons by Champion would cause increases of about 3.6 and 8.6 percent, respectively, in the Clark Fork if all of the solids travelled that far. In light of the earlier analysis which noted a tremendous decrease in Clark Fork suspended solids loads due to settling in the impoundments, it is doubtful that more than a small fraction of the Champion solids would reach that point.

The total calculated yearly TSS and VSS loads at Harper Bridge were about 129,000 and 20,500 tons. Thus, the maximum allowable Champion discharge could be expected to increase those figures by about 1.6 and 9.2 percent on the average. That increase in TSS would be difficult to measure accurately; likewise the VSS also is difficult to measure because the background concentrations tend to be small (1984-1985 average 2.7 mg/1) and the precision of the VSS test at that concentration is not great.

The worst case, or the largest increase, noted in the hypothetical calculations was the month of October where 9.2 and 30.1 percent increases in TSS and VSS were predicted, respectively. These increases would also probably not be accurately measurable because the background concentrations in October were very small (3.1 and 0.9 mg/1 TSS and VSS).

In summary, it is unlikely that even a discharge to the maximum allowable TSS poundage, should it ever occur, would produce a measurable

Table 7. Mean monthly tons of background total and volatile suspended solids in the Clark Fork River and the increases resulting from the proposed discharge.

	Clark Fork River at Harper Bridge	Mean Monthly		Direct Discharge	Mean Monthly			Percent Increase	
	Flow(cfs)	TSS(tons/mo)	VSS(tons/mo)	Flow(cfs) *	TSS(tons/mo) **	****	VSS(tons/mo) ****	TSS	VSS
October	3209	831	241	6.8	92.0	76.4	72.6	9.2	30.1
November	2951	692	406	5.5	72.0	59.8	56.8	8.6	14.0
December	2177	728	364	1.6	21.6	17.9	17.0	2.4	4.7
January	1969	411	263	0.6	8.1	6.7	6.4	1.6	2.4
February	1804	517	190	0.0	0.0	0.0	0.0	0.0	0.0
March	2764	3117	693	4.5	60.9	50.5	48.0	1.6	6.9
April	5921	10340	1819	20.3	265.9	220.7	209.7	2.1	11.5
May	13055	85400	11561	56.0	757.9	629.0	597.6	0.7	5.2
June	14406	21664	3611	62.8	822.5	682.7	648.6	3.2	18.0
July	4339	3044	725	12.4	167.8	139.3	132.3	4.6	18.2
August	2452	1127	287	3.0	40.6	33.7	32.0	3.0	11.1
September	3356	1031	353	7.5	98.2	81.5	77.4	7.9	21.9
Sum(tons)	128902	20513			2407.5 ***	1998.2	1898.4	Average % Increase	
								3.7	12.0

* based on meeting color standard
** based on 162 mg/l TSS maximum monthly average concentraton
*** exceeds yearly load limit
**** reduced by .17 so the total TSS = total maximum allowable yearly load of 4.0×10^6 pounds

impact in the Clark Fork or an exceedence of criteria for the protection of aquatic life. Minimum river dissolved oxygen levels specified in the permit would protect against critical summertime dissolved oxygen reductions; the color standard and the minimum river flow (1,900 cfs) at which discharging could occur would protect against excessive TSS loading during low streamflows occurring at any time of the year.

Dissolved Oxygen

Overview

The amount of dissolved oxygen (DO) in streams is an important measure of water quality. Sufficient levels of oxygen are necessary to support a healthy and diverse community of organisms, including fish, aquatic insects, other macroinvertebrates and plants. Severe depletions of dissolved oxygen can cause fish and insect kills. Chronically low levels can cause a decrease in diversity and quality of aquatic life.

The variables that can affect dissolved oxygen levels are numerous. Water temperature, biologic activity such as photosynthesis and respiration, oxidation of inorganic compounds, decomposition of organic matter, reoxygenation from water turbulence, along with diurnal and seasonal variations interact in complex ways to determine dissolved oxygen concentration. Isolating and measuring the effects of any one variable can therefore become an arduous task, and interpretations of data can be difficult.

An organic wasteload generally has two impacts on the dissolved oxygen levels of an aquatic system. Primarily, oxygen is consumed during biologic decomposition of organic matter into inorganic nutrients. Also, nutrients in the wasteload may stimulate algae growth, exaggerating both photosynthetic oxygen production and the dissolved oxygen maximum during the day and respiratory oxygen demands and the dissolved oxygen minimum at night. Most of the oxygen demand of a wasteload may be satisfied within several miles of the source, with more persistent organics slowly decomposing over time. Further downstream, the complex cycling of nutrients and organic matter may obscure or diminish the effects of an artificial wasteload on the natural stream processes.

Two laboratory tests are commonly used to characterize the organic nature of a wastewater. These are the BOD and the Chemical Oxygen Demand (COD). The BOD of water or wastewater is defined as the amount of oxygen consumed during biologic stabilization (oxidation or decomposition) of oxidizable organic matter present in the water. A higher BOD value indicates a more polluted water than a lower one. The BOD test is a five-day incubation of a water sample, on which a dissolved oxygen determination is made at the start and end. The amount of oxygen consumed is used to compute a BOD value in mg/l of dissolved oxygen. The test is highly empirical, and the five-day BOD value and rate of organic decomposition are dependent on the nature of the waste or water (quantity and character of organic constituents), and the kinds of biological organisms present. The test is performed under constant laboratory conditions ($20^{\circ}C$, no ambient light), therefore care must be taken when

using BOD values to predict oxygen demands in an aquatic environment, where oxygen concentrations are affected by many variables.

The COD is another method of measuring the amount of organic material in a water or wastewater sample. Its advantages are the short (several hour) test duration compared to the five-day BOD test, and applicability to toxic waste loads. In the test, a strong chemical oxidant is used to oxidize organic matter. The result is reported as a value in mg/l of oxygen. COD values are generally higher than BOD values because many organic compounds which are chemically oxidizable are not biologically oxidizable, and because certain inorganic substances may be oxidized during the COD test. Moreover, some biologically oxidizable compounds are not oxidized during the COD test. Therefore, establishing a relationship between the COD and BOD values should be done carefully. If the chemical nature of a wastewater is not highly variable, a rough COD/BOD value can be calculated. COD can be more useful than BOD in stream studies because it is much more sensitive to low levels of organics.

Because of the organic nature of the Champion discharge, the potential impact on dissolved oxygen levels in the Clark Fork would be similar to the impacts of other effluents high in organics.

The data to be discussed concerning dissolved oxygen levels and impact from the Champion discharge are as follows:

1. DO, BOD and COD data from five seasonal comprehensive synoptic[6] sampling runs, shallow water and deep water results included,

2. Two summer, diurnal DO/temperature sampling runs,

3. Champion's above and below "self monitoring" data for dissolved oxygen, and

4. Other related studies and miscellaneous data.

Synoptic Sampling Runs

During the two year study, five synoptic sampling runs provided ambient water quality data on dissolved oxygen, BOD and COD. Because sampling was done at all hours of the day, the diurnal variability of dissolved oxygen becomes a factor and can mask the affects of deoxygenation caused by organic decomposition and makes interpretation of dissolved oxygen changes difficult.

The data from Shuffields (two miles below the Missoula WWTP) to Alberton would best define a zone in which to anticipate a dissolved oxygen impact. At Shuffields it appears from BOD and COD values that the oxygen demand of the Missoula WWTP has been satisfied and further downstream at Harper Bridge dilution from the Bitterroot River has occurred. The first synoptic run (March 1984) occurred during a period of no direct discharge from Champion. Any BOD loading was through seepage and the data could be

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6 A synoptic sampling run is a series of water samples which when timed according to rate-of-flow and distance, enables scientists to sample the same "slug" of water as it flows downstream.

used as background. The last synoptic run (summer 1985) also occurred during a no discharge period although a small amount of effluent (.17 cfs) was leaking into the river through Champion's discharge No. 002. The other three runs occurred during discharge periods when dilution ratios were variable. Several trends are worth noting as shown in Table 8.

Generally, dissolved oxygen levels decreased from Shuffields through the Champion reach and began increasing at Huson for the summer 1984 run. This would be expected because the synoptic sampling through this stretch occurred during the late night/early morning hours when dissolved oxygen levels are approaching a daily minimum. Also, the lower sites (Ninemile and Alberton) show increasing oxygen levels which would be expected because of the diurnal rise beginning near dawn and continuing through the day. Most of the dissolved oxygen variations are consistent with expectations of diurnal changes. One possible discrepancy might be the sag (when organic wastes are introduced which use more DO than expected, graphically depicted as a "sag" in the normal curve for DO) occurring at Frenchtown during the fall 1984 and spring 1985 runs. On the summer 1985 run the sag appeared to be consistent with an early morning minimum. During the Fall 1984 and March 1985 runs, the sags are followed by a small recovery at Huson and another sag at Ninemile. The sags at Ninemile might indicate a diurnal minimum consistent with the time of day and time of year. The sags at Frenchtown appear to be aberrations in a normal diurnal DO curve. This may be due to a measurable demand of oxygen during organic decomposition, because this is the stretch of river in which much of the BOD of the discharge is being satisfied. Also, since this is the mixing zone of the discharge, these values may be from unmixed water and interpretation of these values may not be meaningful.

From Shuffields to Alberton, BOD values are generally below detection limits. Measurable values do not appear to be significant, and values above and below Champion do not show any detectable change. This is probably due to instream dilution, which would render BOD values at even the lowest dilution (511:1) undetectable.

COD values increase from Harper Bridge to Marcure Slough station (0.50 miles downstream from Champion) at the lower dilutions. Decreasing values thereafter probably indicate biological degradation of certain organic components. Two instances of increasing COD values from Huson to Ninemile might indicate another contaminant source or scouring and suspension of algae from the bottom.

The data for BOD, COD and DO suggest that much of the oxygen demand of the organic load from the Champion discharge is satisfied within the mixing zone from Champion to Huson. The effects of instream dilution would diminish the oxygen demand to nearly unmeasurable levels. The COD test provides an indirect measure of satisfied oxygen demand. As values at Harper Bridge and Huson are similar, it is possible that much of the BOD is satisfied before Huson. A slight elevation in COD values thereafter may indicate scouring and suspension of algae. Further, a slight decrease in DO values at Frenchtown may define the zone of oxygen demand.

Table 8. Summary of five synoptic sampling runs in the Champion area, including concentrations of BOD, COD, DO, sampling time and dilution ratio for the Champion Discharge.

	Shuffields	Harper Bridge	Champion Discharge	Marcure	Frenchtown	Huson	9 Mile	Above Alberton
March 1984								
DO	13.5	13.7	0[1]	12.3		12.0	12.1	12.5
BOD	<2	2.3	113	<2		<2	<2	<2
COD	<5	<5	852	18.4		<5	<5	<5
Time	1115	1745	no discharge	2000		0015	0300	0500
July/Aug 1984								
DO	9.40	8.90	0	8.10	10.20	7.75	7.55	8.10
BOD	<2	<2	38.9	<2	<2	<2	<2	<2
COD	<5	<5	567	<5	<5	<5	<5	7.4
Time	1655	2130	3830:1[2]	2330	1650[3]	0400	0710	0900
Oct/Nov 1984								
DO	12.10	11.70	0	11.30	11.20	11.35	11.05	11.70
BOD	<2	<2	65.5	<2	<2	<2	<2	<2
COD	<5	<5	795	8.2	5.8	<5	5.7	5.3
Time	1800	2230	511:1	0015	0145	0315	0700	0900
March 1985								
DO	13.10	11.50	0	10.95	10.65	10.80	10.65	11.20
BOD	2.5	<2	67.5	2.5	2.5	2.5	2.9	2.7
COD	11.9	12.0	755	15.3	11.0	11.5	13.3	15.3
Time	1715	2150	971:1	2305	0100	0330	0700	0900
July/Aug 1985								
DO	9.25	8.20	0	7.40	7.15	7.40	10.05	10.40
BOD	<2	<2	134	<2	<2	<2	<2	<2
COD	5.6	<5	871	<5	<5	<5	<5	<5
Time	1915	0100	8706:1	0330	0500	0730	1330	1530

1. DO not run on discharge due to color interference
2. Dilution Ratio River:Waste
3. Off of synoptic schedule

Deep Water Dissolved Oxygen

Dissolved oxygen measurements in Clark Fork River pools and mainstem reservoirs were taken as part of the first two comprehensive sampling runs (March 1984 and July 1984). During the fall 1984, spring 1985 and summer 1985 runs, river pool monitoring was dropped, but reservoir sampling continued.

The concern with DO levels in more static aquatic environments, such as river pools and reservoirs, centers on their role as natural sediment traps. Organic solids accumulate in such environments and under proper conditions, biologic decomposition can reduce or even deplete DO concentrations. Theoretically, an impact of a discharge such as Champion's can be direct, through downstream settling of solids, or indirect, through stimulation of algae growth from nutrients present in the wastewater and accumulation of these algal solids in more static environments.

River pool and reservoir DO measurements were taken near the top and bottom of the water column being sampled to determine whether significant differences in DO levels attributable to benthic (bottom) decomposition of organic sediment were evident. A review of the deep water data shows only minor top to bottom changes in DO, generally a few tenths of a milligram per liter, or less, with no direction of change seeming to predominate. Two instances of more severe change occurred in Noxon Reservoir during each of the summer runs. The top to bottom decrease was 1.3 mg/l in 1984 and 1.4 mg/l in 1985. This change is significant compared to the average top to bottom changes of a few tenths of a milligram per liter, but the bottom concentration of 7.1 mg/l is above the water quality standard and temperature readings do not indicate a firmly stratified condition which would prevent reoxygenation. When considered with data on TSS loadings into and out of Noxon Reservoir, which establishes its significance as a sediment trap for the Clark Fork River system, these depressions indicate a probable cause-effect relationship between the organic loadings and bottom DO levels.

Data collected by the Clark Fork River Watchers, a volunteer citizen group based in Plains, do not show any unusual DO levels from St. Regis to Plains inconsistent with expected seasonal or diurnal variations.

Diurnal Dissolved Oxygen Runs

A diurnal DO monitoring run was conducted in August of each study year to determine daily oxygen maximums and minimums at sites above and below Champion.

The low flow, high temperature conditions characteristic of August can be stressful to aquatic life. Dissolved oxygen levels in the river are near the annual minimum, and impacts from oxygen-demanding organic decomposition and increased respiration of plants and animals become potentially more severe.

An impact from the wastewater discharge on instream DO levels would presumably appear as a sag caused by biological decomposition of organic matter or as a distortion in the daily DO cycle caused by increased community photosynthesis and respiration.

The conditions existing during these runs were not ideal. In 1984, the dilution of the Champion discharge was quite high (2,352:1), minimizing the possibility of detectable impacts. In 1985, air temperatures were down a bit from highs established several weeks earlier, and water temperatures were probably a bit lower also. As Champion was not discharging at this time (river flow about 1,800 cfs), information about a "no-discharge" type of situation was obtained.

The time-weighted DO values calculated from a set of instantaneous readings made over the course of a day are useful because they provide a more thorough picture of oxygen levels over the course of a day than the instantaneous readings alone. As averages, though, they do not provide the information about the daily range of DO values that the instantaneous readings provide. A comparison of these time-weighted values shows no obvious trends from one year to another or between sites above and below Champion. Mean DO values are a bit higher in 1985 than in 1984, and this is true for sites immediately above Champion as well as below. Values above and below Champion are comparable both years; no unusually high or low mean values occur. Only twice was the 7.0 mg/1 DO water quality standard met or exceeded--in 1985 at Harper Bridge (6.8 mg/1) and in 1984 in the Flathead River (6.9 mg/1). Neither site is influenced by the Champion discharge.

There seems to be a consistent narrowing of the diurnal DO range as one travels downstream from Turah (Figure 15). This trend did not occur in 1984 and the cause is not obvious. A narrowing of the diurnal temperature range could explain this, but this did not happen. A less productive community would decrease photosynthetic oxygen and lessen respiration demands, producing less dramatic maximums and minimums.

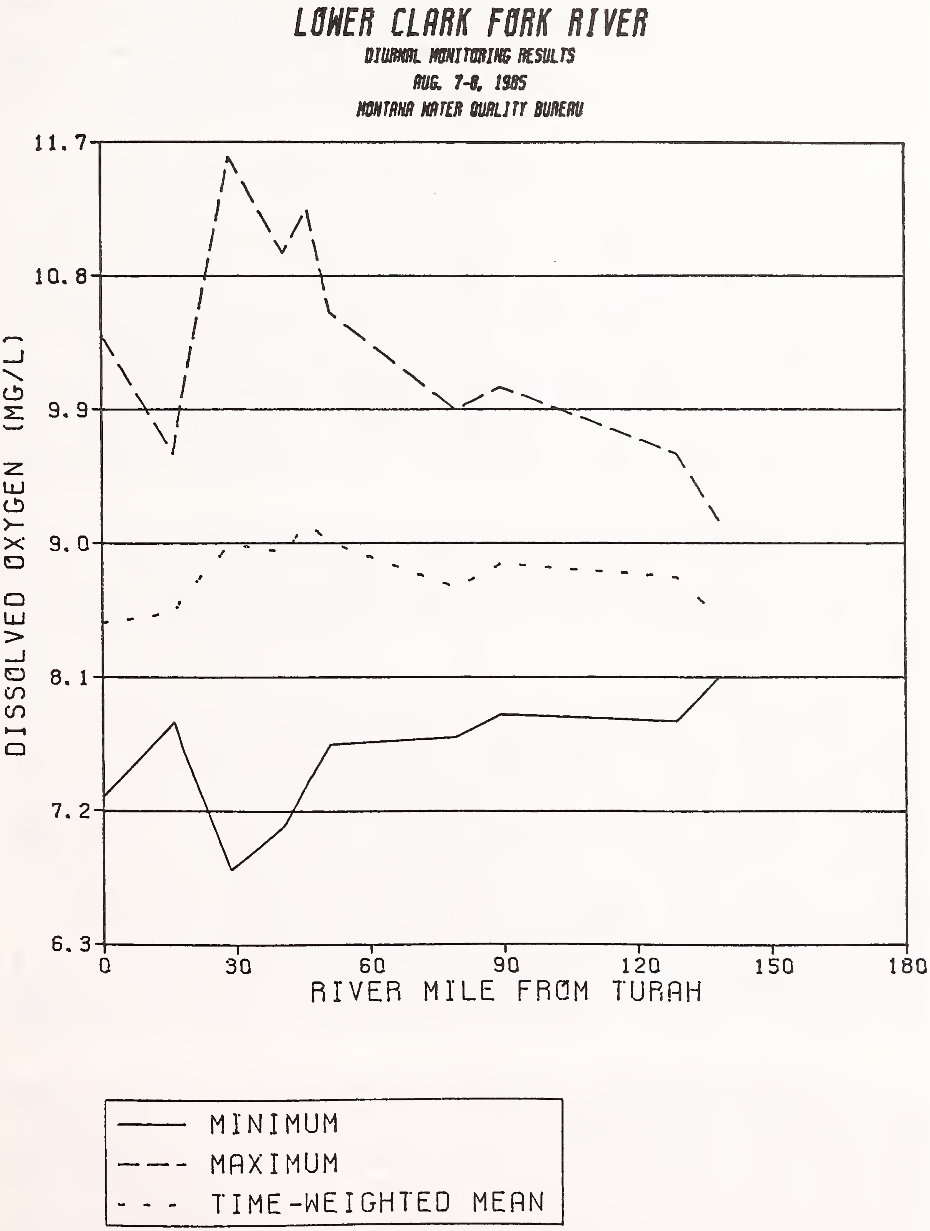
An inspection of the 24-hour DO curves reveals the site- to-site and year-to-year variability of diurnal fluctuations. In light of this variability, it is difficult to distinguish natural variation from induced variations. The diurnal range at Huson is a bit smaller than the range at Harper Bridge for both years. This variation does not appear to be abnormal and is the opposite of the effect expected from nutrient stimulation.

The diurnal DO monitoring runs did not indicate a problem with DO levels in the Clark Fork River. A particular deficiency of these runs was the lack of any appreciable discharge at the time they were done. In fact, both runs are close approximations to "no discharge" situations. Further monitoring of this kind might be necessary during discharge periods of low instream dilution.

Champion's Self Monitoring Data

Champion as a condition in its discharge permit, is required to monitor for DO during periods of direct discharge above and below the outfall (Harper Bridge and Huson), twice weekly when the river DO level is less than 10 mg/1, and weekly when the river DO level is at or above 10 mg/1. This sampling is done one hour before sunrise when the daily minimum is usually reached. It is the most comprehensive data available for analyzing DO changes along this reach of river, and under different discharge conditions.

Figure 15


LØWER CLARK FØRK RIVER
DIURNAL MONITORING RESULTS
AUG. 7-8, 1985
MONTANA WATER QUALITY BUREAU
11.7
10.8
9.9
9.0
8.1
7.2
6.3
DISSØLVED ØXYGEN (MG/L)
0
30
60
90
120
150
180
RIVER MILE FRØM TURAH
MINIMUM
MAXIMUM
TIME-WEIGHTED MEAN

The "self monitoring" reports from January 1984 through September 1985 include 178 days of above and below DO testing. In Table 9, the frequency of a negative change, no change, or positive change in DO levels from Harper Bridge (above) to Huson (below) have been calculated for different river flow to waste flow dilution ratios, and for instances where no surface discharge is occurring. The rationale for this comparison is to test the anticipation that at lower levels of dilution, a greater frequency of negative changes would occur than at higher dilutions, and fewer frequencies of positive changes would occur.

Table 9 presents the distribution of the change in DO concentrations over a range of instream dilution ratios, and for each range an average change in DO concentration for all samplings within that range. A chi square evaluation was done to test for a relationship between the dilution ratio (an indirect measure of instream waste strength) and direction of change in DO level between Harper Bridge and Huson. The final chi square value (X^2=17.88) was significant at the .05 (5%) level of probability, which indicates a significant relationship between the two variables. This relationship should not be entirely surprising, since BOD loadings do require DO during their decomposition. Because this sampling data was not collected under strictly controlled conditions, other variables are undoubtedly a factor in the distribution of data. A more complex analysis, and perhaps more data, would be required to establish other relationships affecting DO levels here.

The self-monitoring data also reveals that during twelve days, the DO was at or below the 7.0 mg/l water quality standard. During nine of these days no waste was being discharged. The report shows no instance of a discharge occurring during a DO level below 7.0 mg/l at either station.

Summary of Findings

From the information presented, it is doubtful that the Champion discharge results in any significant changes in DO concentrations in the Clark Fork River below the discharge. A study done by Kicklighter and Stanford (1985) (The Use of Riffle Community Metabolism as a Measure of Water Quality Degradation in the Clark Fork River, Montana) concludes that changes in benthic community metabolism due to the addition of kraft mill effluent were negligible. Their methods were not sensitive enough to measure metabolism in the water column. The five synoptic sampling runs show DO concentrations generally consistent with seasonal and diurnal variations. Champion's self-monitoring data of DO above and below the discharge show only minor dilution-dependent changes in DO levels. Two diurnal DO/temperature monitoring runs, in spite of some weaknesses, showed no detectable DO impact. Bottom DO levels in Noxon Reservoir showed some depression.

Several anomalies might need further investigation. The small DO sags which occurred in the Frenchtown area during two synoptic sampling runs were inconsistent with expected diurnal variations although a "natural" cause cannot be ruled out. It is possible much of the oxygen demand of the BOD loading is satisfied here rather than further downstream. This reach of river is still within the permitted mixing zone of the discharge, and it is possible that oxygen demand of the organic load is reduced significantly

Table 9. Frequency of changes in DO levels between Harper Bridge and Huson and instream dilution of Champion discharge, with average change in DO concentrations for each dilution range. Column percentages in parentheses.

Dilution	Decrease in DO	No Change in Do	Increase in DO	Total	Average mg/1 DO
200-400:1	14 (29.2)	15 (30.0)	10 (12.5)	39 (21.0)	-0.028
401-600:1	7 (14.6)	14 (28.0)	14 (17.5)	35 (19.7)	+0.037
600-800:1	10 (20.8)	11 (22.0)	14 (17.5)	35 (19.7)	+0.043
801-1000:1	2 (4.2)	2 (4.0)	8 (10.0)	12 (6.7)	+0.125
1000:1 (including no discharge)	15 (31.3)	8 (16.0)	34 (42.6)	57 (32.0)	+0.093
TOTALS	48(100.1)	50(100.0)	80(100.1)	178(100.0)	+0.048

by the time mixing is complete at Huson. This is further supported by comparable instream COD values at Harper Bridge and Huson.

One area which deserves further consideration is the BOD character of the wasteload during the study period. From January 1984 to September 1985, the average BOD of the combined discharges (001 and 003) was about 59 mg/l. Discharge permit limits allow a maximum daily concentration of 161 mg/l and a maximum 30 day average concentration of 87 mg/l. Assuming a "worst case" scenario of a 200:1 dilution ratio of a waste stream of 161 mg/l for a significant period of time and a river BOD of 2 mg/l (minimum detectable concentration), the calculated BOD of the river after complete mixing would be:

$$\frac{200(2\ \text{mg/l}) + 1(161\ \text{mg/l})}{201} = 2.79\ \text{mg/l}$$

This value assumes no decomposition in the mixing zone from Champion to Huson. Immediate satisfaction of this .8 mg/l increase in BOD would lower DO values correspondingly. However, it seems likely that much of the BOD is satisfied in the mixing zone and the remaining BOD would be exerted over several days, producing only very minor changes in DO levels.

Color

The five color unit increase allowed Champion International in the Clark Fork River between Harper Bridge (control station) and Huson (downstream station) is one of the most stringent color standards in the nation. Water with five units of color does not look colored to most people and has virtually no effect on aquatic life. Champion attempts to meet this standard by instream sampling and concurrent adjustment of discharge flow.

Color is the single most important factor controlling the rate at which Champion can discharge wastewater to the river. Assuming no color in seepage and 1,500 units of color in the discharge (the 1984-1985 average), Champion cannot discharge more than one part of wastewater for every 300 parts of river water passing the mill.

The seepage does in fact contribute significantly to river color during low flows, although seepage does remove a considerable amount of the wastewater color, and discharge color does exceed 1,500 units at times. Hence Champion usually needs more than 300 parts of dilution water for every part of wastewater discharged in order to meet its permit requirements for color, especially at low flows. Because of reductions in pond seepage and rapid infiltration, Champion no longer violates the instream color standard when it is not discharging at flows less than 1,900 cfs.

Champion has reported occasional violations of the allowed five color unit increase over the term of the current permit. These violations were underscored in a letter to Champion dated August 2, 1985. For the 12-month period ending July 1, 1985, Champion responded as follows:

1. Champion has measured the color increase twice per day throughout the time period.

2. The upstream color has ranged from five to 30 SCU.

3. The color test is accurate only to plus or minus 1 SCU.

4. Ninety-eight percent of all measurements were at or under the five SCU increase.

5. All those measurements exceeding five SCU were measured at six SCU.

6. Immediate corrective action has been taken in all cases where the color increase exceeded five SCU.

The response concluded that Champion is constantly striving to reduce the volume and color of its effluent and that continued compliance with the color standard is "a very high priority" (Letter from Daniel T. Potts, Vice President/Operations Manager, Champion International Corporation, August 9, 1985).

Toxics

Ammonia

Ammonia occurs in natural waters as a byproduct of biological degradation of organic wastes. In unpolluted waters the concentration of ammonia is very low, usually well under 1 mg/l. Elevated levels of ammonia are often associated with wastewaters high in organics. For example, the Missoula WWTP effluent during this study contained from 0.8 mg/l to 19.3 mg/l in total ammonia. Total ammonia concentrations in the Champion effluent ranged from about 2.2 mg/l to 8.6 mg/l. Background levels of ammonia in the Clark Fork River are generally less than 0.05 mg/l.

Ammonia can be toxic to aquatic life, depending on concentration, pH or water temperature. A water solution in which ammonia is present contains two forms of the compound, ionized (NH_4^+) and un-ionized (NH_3). The equilibria between these two forms of ammonia is directly related to pH and temperature. The un-ionized form is the most toxic to aquatic life. It's concentration increases with a rise either in pH and temperature. The pH range of most natural waters is such that the ionized form, NH_4^+, predominates.

The water quality criteria[7] for un-ionized ammonia (as developed by the EPA and published in the Federal Register, July 29, 1985) reveals its temperature-pH dependency.

Figure 16 shows the relationship between pH and total ammonia concentration. The temperature curves represent the total ammonia concentrations which will yield un-ionized ammonia at criteria levels, when pH values range between 7.5 and 9.0. Data points for Shuffields and Huson,

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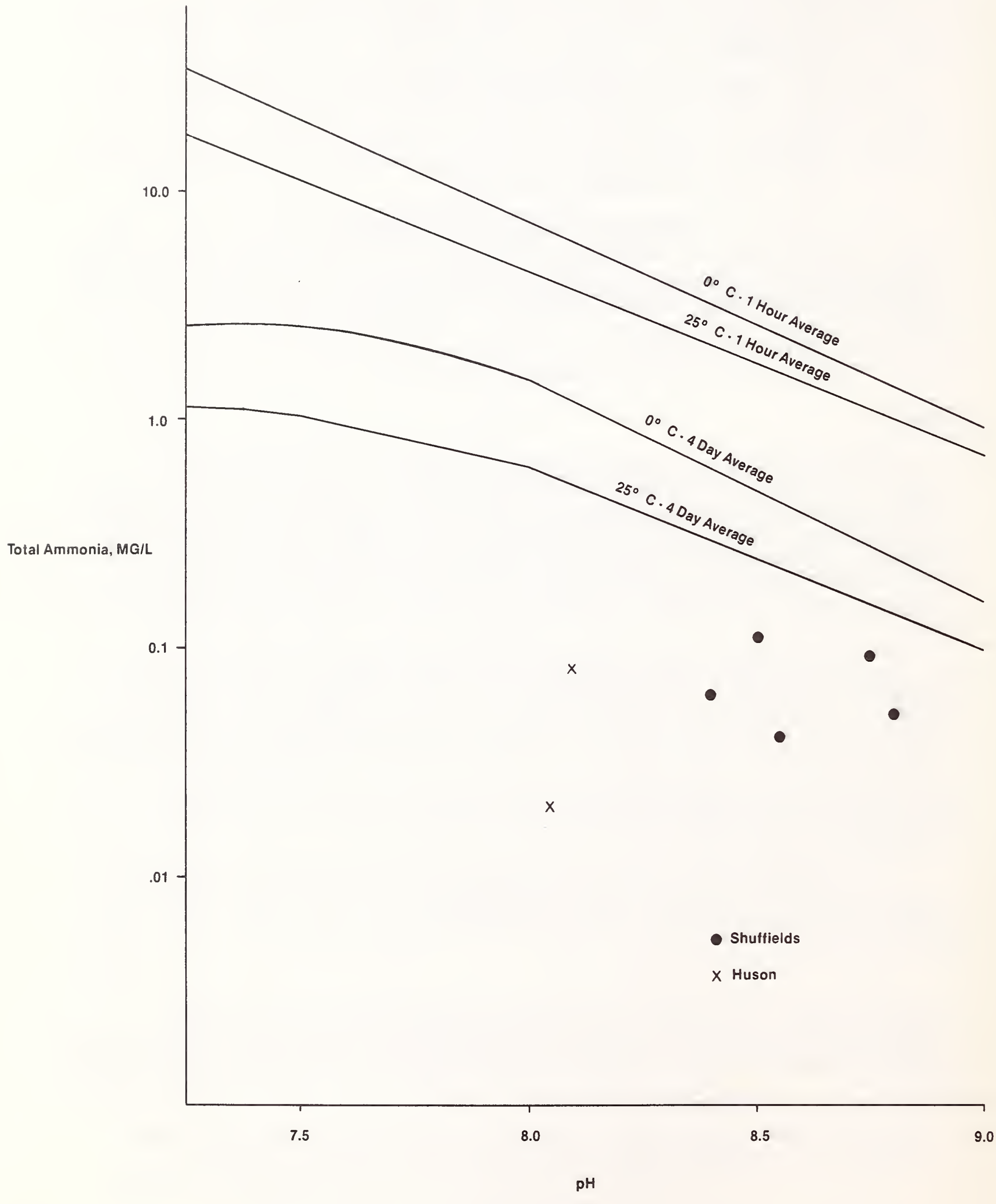
7 Criteria for water quality parameters are scientifically determined levels or concentrations of physical, chemical or biological characteristics from which the suitability of water quality and water quantity is assessed for a particular use. (Flathead River International Study Board, memo, November 1, 1985)

Figure 16. Total ammonia curves for 0°C and 25°C equivalent to water quality criteria for one hour and four day average concentrations of unionized ammonia.



and associated temperature values in degrees centigrade (^{o}C) are plotted. These points fall well under the criteria curves for both one-day average and four-day average concentrations. The statistical summary (Data Report, Volume 1) shows a maximum ammonia value of 0.08 mg/l at Huson over 25 sampling dates and no higher values downstream to the mouth of the Flathead River area. At this level, it would require an unexpectedly high temperature and a very high pH to exist before the un-ionized ammonia criterion is met.

A "worst case" situation might be a high ammonia discharge from Champion into the Clark Fork at a time of unusually high instream ammonia levels. This calculation assumes an instream ammonia concentration of 0.04 mg/l (maximum measured at Harper Bridge), a discharge concentration of 8.6 mg/l (maximum level measured at Champion), and a dilution ratio of 200:1, the theoretical minimum dilution.

$$\frac{200(.04) + 1(8.6)}{201} = \frac{16.6}{201} = 0.0826$$

This concentration is the same as the maximum measured value at Huson and, as previously mentioned, would require unusual temperature/pH conditions for the un-ionized ammonia criterion to be met. Assuming an instream pH of 8.5 and temperature of $20^{o}C$, the four-day criterion for total ammonia is 0.32 mg/l. This would require a concentration in the discharge of 64 mg/l at a 200:1 dilution. This is approximately seven times the maximum value measured to date. The data suggest that ammonia in the Champion discharge does not pose a toxicity problem.

Metals

Metals have been present throughout the Clark Fork River Basin for many years. It is well known that copper mining and smelting activities in the Butte, Anaconda and Philipsburg areas, beginning in the late 1800's, were the major contributors of the metals present in the system today. Elevated concentrations of metals have been detected as far downstream as Thompson Falls, Noxon, and Cabinet Gorge Reservoirs. Due to the potential toxicity of some of these metals to aquatic life, their measurement is important in determining the health of an aquatic system.

Iron and manganese are toxic only at concentrations much larger than those recorded in the lower Clark Fork. Copper, zinc, cadmium, lead and arsenic can cause both acute and chronic toxic effects to aquatic organisms at much smaller concentrations.

The concentration at which a metal is toxic is significantly dependent on the hardness and alkalinity of the water. Other factors such as the species of organisms present, chemical form of the metal, the presence of complexing agents such as dissolved and undissolved organics, and factors affecting organism metabolism (temperature and dissolved oxygen) may also influence the effective concentration.

Heavy metal toxicity has been more of a concern in the upper Clark Fork River then in the lower reaches. From Butte to the Milltown Dam the river is a free flowing stream. Normal stream processes have acted for years to move sediment and heavy metals downstream from Butte. Milltown

Dam has altered these normal processes, acting as a "sediment trap" and effectively preventing much of the metals load from entering the lower Clark Fork System. Also, the inflow from two major rivers, the Blackfoot and Bitterroot Rivers, assures a steady source of clean dilution water which further reduces the impact of metals from the upper Clark Fork River downstream from Milltown Dam.

Total Metals Loadings

The contribution of heavy metals made by the Champion discharge to the Clark Fork River is small. Calculations of annual amounts of metals in the river at Harper Bridge and additional amounts of metals from the Champion discharge reveal increases of about half a percent over background levels for most metals.

Water Quality Criteria

The EPA has also recommended water quality criteria for arsenic, cadmium, copper, lead, and zinc. Revised criteria for all metals except zinc were released July 29, 1985 (Federal Register). Criteria for zinc have been effective since 1980.

The criteria for all metals suggest both acute (one-hour average or instantaneous) maximum limits and more stringent, chronic (generally four-day) maximum average values. The criteria concentrations for all metals except arsenic are calculated using a formula based on the hardness of the water, recognizing that a given concentration of a metal is more toxic in softer water and less toxic in harder water.

Figures 17-20 show the criteria levels for metals and data points at Harper Bridge and Huson. Lead and zinc values are well below criteria levels. The plots for cadmium and copper show several exceedences of the acute and chronic criteria. Most of the values exceeding the acute criteria occurred during high flow, spring runoff when hardness values decline from snowmelt dilution and sediment metals loads increase because of higher flow velocities.

The exceedences of the recommended criteria for cadmium and copper indicate that a toxic condition may have existed. However, exceedences of acute criteria are infrequent and exceedences of chronic criteria were not prolonged. And, studies of indigenous algae and invertebrates that are exposed to these toxic chemicals did not uncover any signs of stress in the river's biological communities.

Arsenic concentrations are well below criteria levels--360 micrograms per liter (ug/l) (1 hour average) and 190 ug/l (4-day average)--for trivalent inorganic arsenic. Maximum concentrations sampled in the Champion area are 10 ug/l.

The chronic criterion for zinc, a 24-hour average, is 47 ug/l. On several occasions in the spring and summer of 1984 this level was exceeded. It appears that the source was significantly above the Champion site and may also be explained by spring runoff.

Figure 17. **One hour and four day average concentration curves, based on water quality criteria for cadmium.**

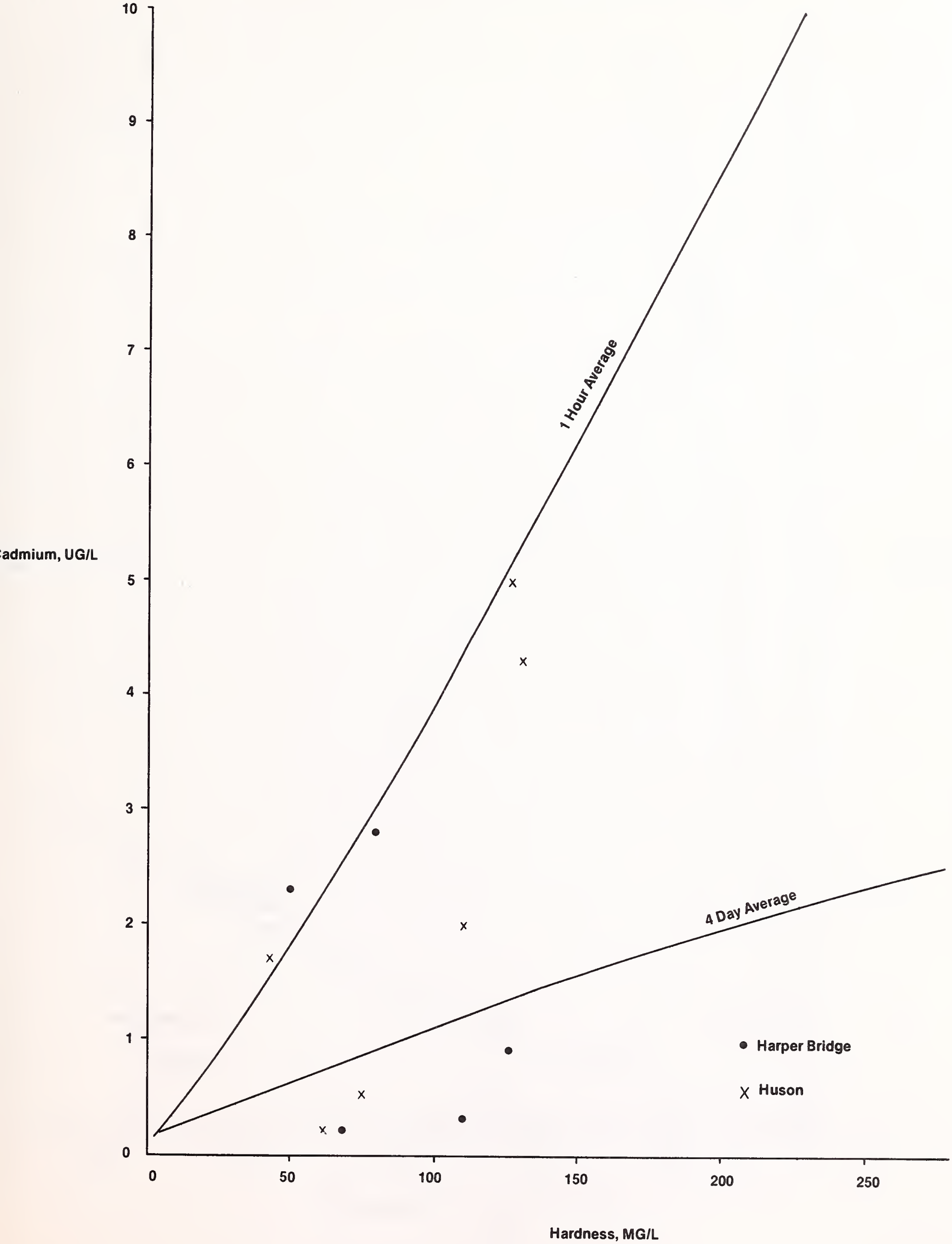


Figure 18. One hour and four day maximum concentration curves, based on water quality criteria for lead.

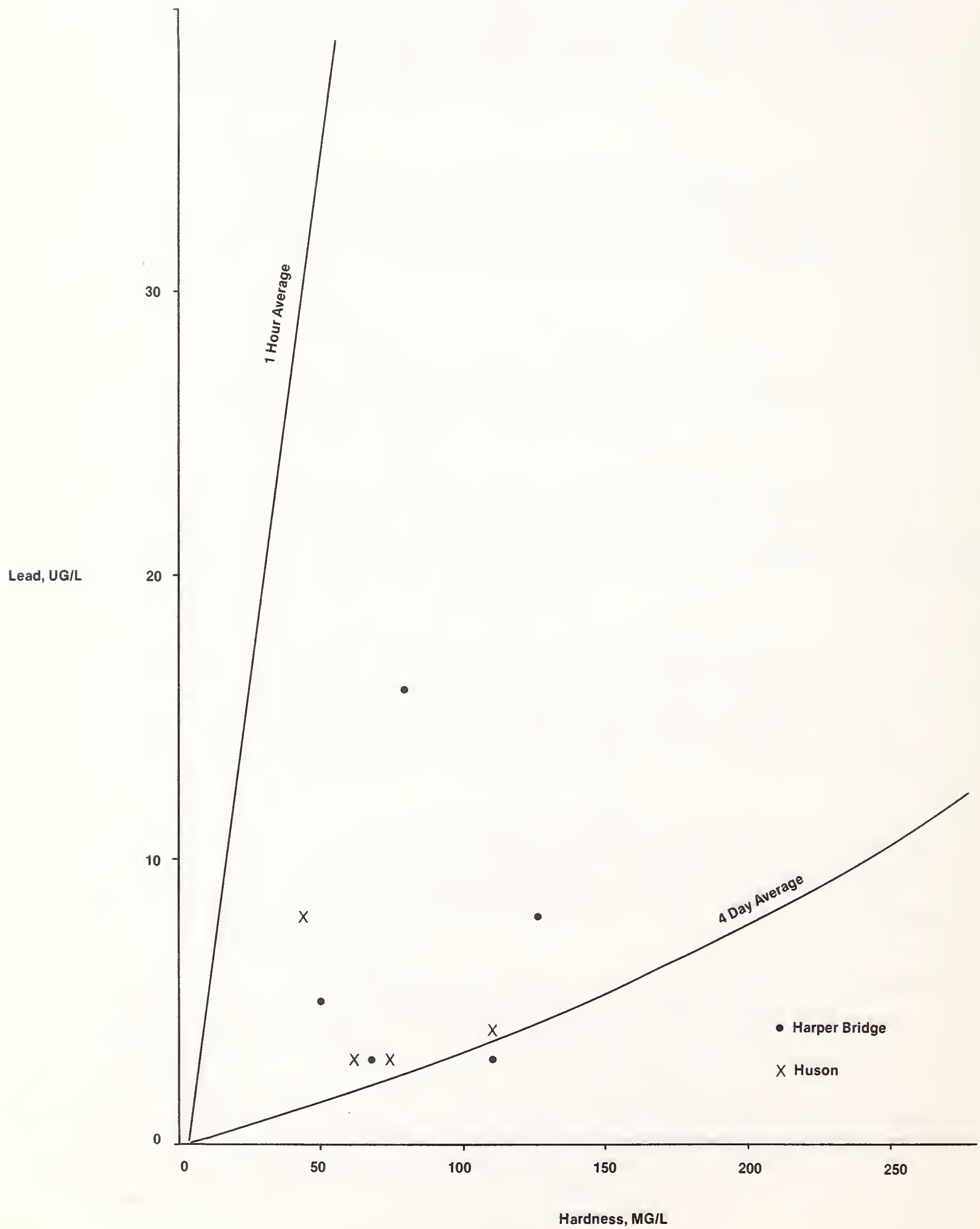


Figure 19. **Maximum instantaneous concentration, based on water quality criteria for zinc.**

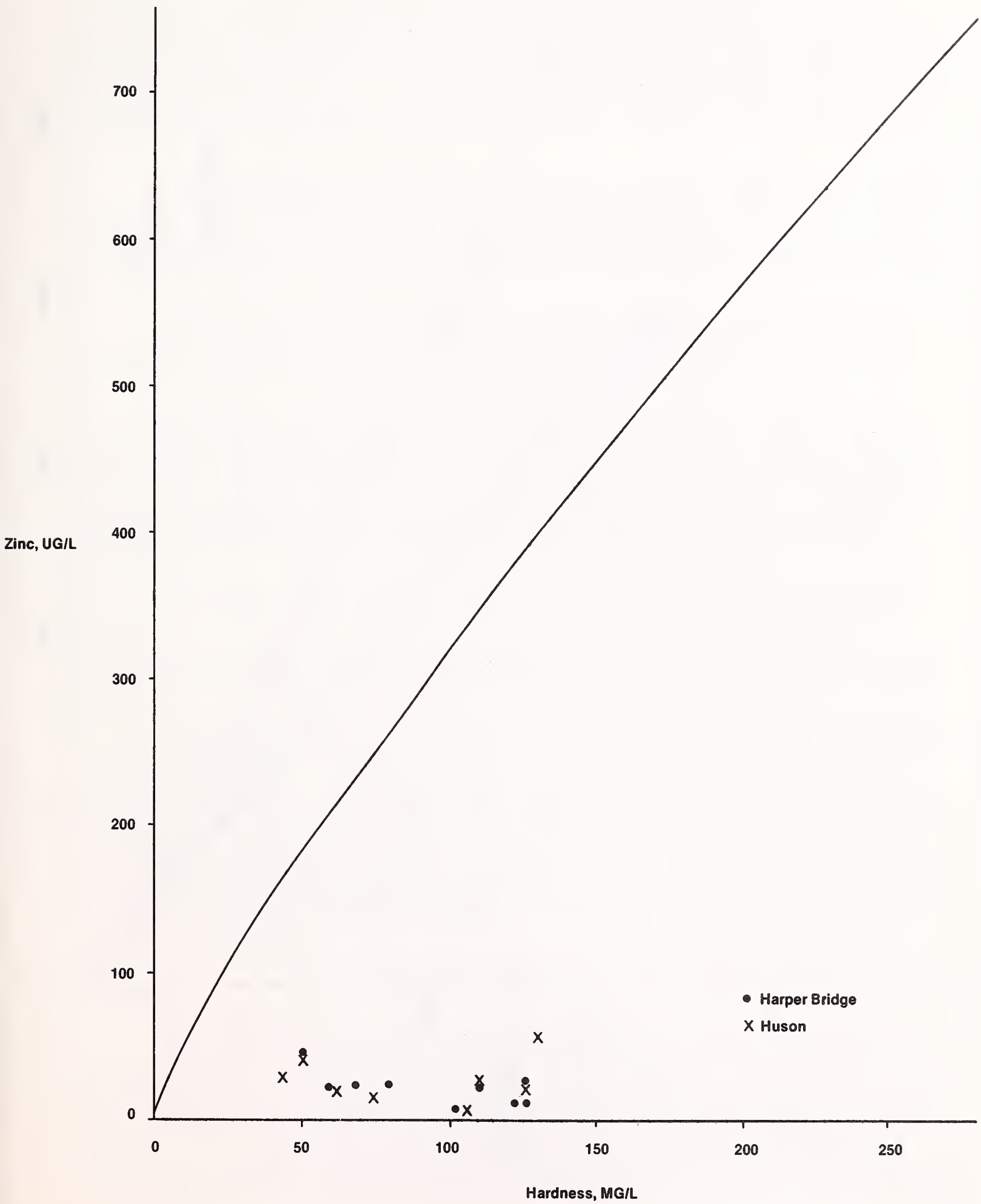
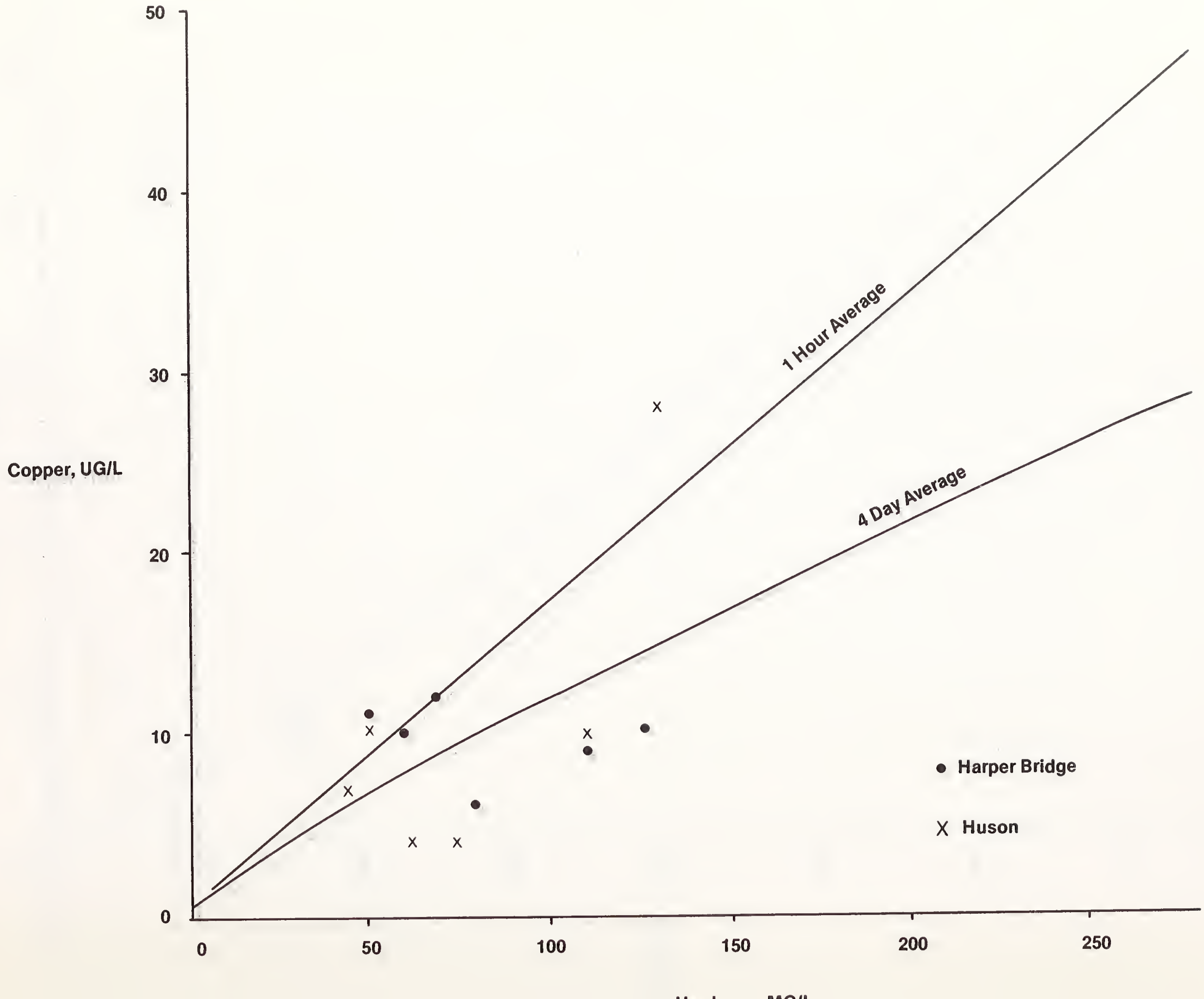


Figure 20. **One hour and four day maximum concentration curves, based on water quality criteria for copper.**



Bioassay

In May 1985 the Water Quality Bureau (WQB) and EPA conducted a chronic bioassay at Champion to determine whether toxicity was exhibited by Champion effluent and Clark Fork River water on two species of test organisms--rainbow trout and water flea (Ceriodaphnia spp). The bioassay was planned to coincide with high flow and runoff conditions when elevated metals concentrations make the river water potentially more toxic than at other times of the year. Due to the unusual drought conditions during the spring, anticipated high flows never developed and the value of the data was somewhat diminished.

The Ceriodaphnia spp. bioassay measures reproductive success of a very sensitive pond organism over a seven day period. River water was collected daily at eighteen sites from Butte to Noxon Reservoir. A second test involved a series of dilutions of Champion effluent, using both well water and river water.

The test involving river water concluded that the only significant change in reproduction, between sites above and below Champion, was an increase in reproductive success at Huson, below the mill.

The Champion waste dilution test was partly invalid because of mortality in the control solutions of uncontaminated well water. However, the test using uncontaminated river water for control and dilution was successful and concluded that the only significant decrease in reproductive success occurred at a 200:8 (4 percent) waste to river water dilution. This is eight times the concentration that would occur at a minimum dilution of 200:1 during discharge to the Clark Fork River.

The rainbow trout bioassay indicated that significant differences occurred in a measure of growth between the control group and the test groups of fish, but that there was no relationship to the amount of wastewater dilution. These interpretations have an element of uncertainty because of procedural problems which occurred during the test.

Preliminary findings in the DFWP fish egg bioassay conclude that brown trout egg survival rates were less and brown trout embryo development slower at two sites downstream from Champion compared to a control site above Champion. At this time, not enough information on intergravel water chemistry has been collected and not enough sites have been examined to explain the observed difference. During the 1985-1986 brown and rainbow trout egg incubation periods, intergravel water quality will be studied at more sites above and below Champion to determine whether toxic agents are present and whether Champion discharge and seepage affect trout reproductive success.

Organics

Much research has been done on the organic and toxic constituents of wastewater from pulp and paper mills. Only a few of the priority pollutants have been detected at significant levels in such effluents. Of the other organic constituents, resin acids, unsaturated fatty acids and their derivatives are of most concern. These acids occur naturally in wood, and are often not totally destroyed in the pulping or wastewater treatment process. Their toxicity to aquatic life has been well documented

and the presence of resin acids in the Champion effluent merits consideration.

During the water quality study and fish bioassay, several samples of Champion wastewater and Clark Fork River water were taken to determine the presence and concentrations of organic constituents. These analyses were done by EPA's Region VIII laboratory in Denver. Samples were analyzed for the priority pollutants and scanned for other non-priority organics. Champion also submitted self monitoring data for organic and priority pollutants.

Analyses of the Champion wastewater show none of the 113 priority pollutants occurring at detectable levels. Three scans for other organics identified approximately 20 compounds of three general groups--natural acids, ketones, and alcohols. Four of these compounds are resin acids. Their average concentrations in the Champion effluent were:

Dehydroabietic acid (DHAA) - 1,018 ug/l
Isopimaric acid - 143 ug/l
Pimaric acid - 560 ug/l
A compound similar to pimaric acid - 190 ug/l

The lethal concentration causing fifty percent mortality in rainbow trout during a 96 hour bioassay (LC-50) for the above compounds are 500 ug/l (isopimaric acid), 80 ug/l (pimaric acid) and 1,200 ug/l DHAA. Instream dilution of the Champion discharge would reduce concentrations of these compounds to levels far below LC-50 values. Research has also indicated that concentrations of resin acids below 1 mg/l (1,000 ug/l) do not present an acute toxicity problem. Instream dilution would reduce the levels of resin acids, as measured in the Champion waste, to levels well below 1 mg/l.

Several possible problems with resin acids are environmental persistence, bioaccumulation, and chronic toxicity. Research has established that DHAA accumulates in fish organs. However, the literature on toxicity of bioaccumulated resin acids and very low level exposure affects is scarce.

Research in Helsinki, Finland,[8] concluded that 20 ug/l was close to the minimum effective concentration of DHAA to rainbow trout, based on observed physiological changes in a 30-day bioassay using DHAA concentrations averaging 20 ug/l. At levels of DHAA detected in Champion's effluent, it seems likely that instream concentration would be below this 20 ug/l "threshold." Questions that remain unanswered due to the lack of research or published findings include:

--Is there chronic toxicity to aquatic life at low levels of exposure (several to tens of parts per billion) to DHAA or resin acids?

--Are there chronic affects of bioaccumulated DHAA and total resin

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8 Oikari A., Lonn B., Castren M., Nakari T., Snickars-Nikinmaa B., Bister H., Virtanen E., Div. Physiol., Univ. Helsinki, Helsinki, Toxicological effects of dehydroabietic acid (DHAA) on the trout, Salmo sairdneri

acids in fish or other aquatic life?

--What are the affects of DHAA stored in bottom sediments and its toxicity to benthic organisms?

One anomaly is the presence of the priority pollutant bis(2-ethylhexyl)phthalate (DEHP) in the Clark Fork River at Harper Bridge (2.5 ug/l) and in the bioassay well water (36.1 ug/l). It did not show up consistently in the Clark Fork River or in wastewater samples taken by the DHES, but it does appear in Champion's monitoring data (77 ug/l) of the discharge.

DEHP is a phthalate ester, and is commonly used as a plasticizer (an additive that gives rigid plastic flexibility). Its migration out of plastics is slow, although soluble complexes may aid their mobility. The water quality criteria for DEHP are 940 ug/l (acute) and 3 ug/l (chronic). Its origin at this time is unknown. EPA's Denver office reports that it is common in the environment and could have resulted from sample contamination in the lab or field.

Champion's self monitoring data shows several other compounds to be present in trace amounts which were not detected in EPA's analyses. Some of these are low levels of chlorinated organics.

Phenol has been detected at a low level in the Champion effluent. Self-monitoring data reports a concentration in the wastewater of 114 ug/l from only one tested sample. Instream dilution would decrease this concentration of phenol below the criterion level of 1 ug/l, which was determined adequate to protect human health and to prevent tainting of fish flesh. Because of the deficiency of data, more information is necessary to adequately characterize the occurrence of phenol in the Champion wastewater.

Hydrogen Sulfide

Hydrogen sulfide (H_2S)is a common constituent of kraft mill effluents. It is also toxic at low levels to aquatic life. Its concentration depends on temperature and pH and can be calculated if the concentration of total dissolved sulfides is known.

Champion's monitoring data since April 1984 includes 35 days of dissolved sulfide monitoring during direct discharge. Although no pH and temperature values for the Clark Fork River are available for most of these days, a theoretical instream hydrogen sulfide concentration can be calculated using the known instream dilution and the hydrogen sulfide/total dissolved sulfide ratio for a given pH and temperature value. A hypothesized pH of 8.0 and temperature of 5.0^{o}C are not the predominant conditions in the Clark Fork River, but are realistic.

The calculations show that on seven of the 35 days the instream concentration of hydrogen sulfide would have been greater than 1 ug/l and on only one day would it have been greater than 2 ug/l (2.07 ug/l calculated). As temperature and pH are generally higher than those hypothesized above, these values are probably artificially high. In fact,

using an average pH value of 8.2 at Huson, only three exceedences of the 1 ug/l level are calculated.

The EPA recommends a limit of 2 ug/l H_2S for protection of all fish species and benthic invertebrates except in areas used for reproduction by fish, where a 1 ug/l concentration should not be exceeded. In well oxygenated streams hydrogen sulfide is rapidly oxidized to sulfate ($SO_4^=$), a nontoxic compound. Because of the number of variables affecting instream hydrogen sulfide concentrations (dissolved sulfide concentration in the waste, pH, temperature, instream dilution ratio, oxidation rate of H_2S), it is difficult to predict the levels of H_2S occurring in the Clark Fork River below Champion. A hypothetical calculation indicates that frequent exceedences of EPA's recommended instream limits are unlikely. (Refer to the Air Quality Section for information on the affects of hydrogen sulfide on air quality.)

Summary

Ammonia and metals in the Champion wastewater discharge do not appear to present a toxic threat to the Clark Fork River. Lack of published data on the toxicity of low level of resin acids the affects of bioaccumulated acids, and sediment-bound acids precludes any definite conclusions about their impact, although an acute problem appears unlikely. Champion self monitoring data indicate that the levels of dissolved sulfide in the effluent may result in instream concentrations above water quality criteria under certain temperature and pH conditions.

Bioassays can be the best indicator of toxicity because they are designed to approximate real conditions while providing the opportunity for in-depth scientific scrutiny. Results of several bioassays performed during the study indicate that Champion wastewater does not have a toxic effect at a 200:1 dilution level or greater. The *Ceriodaphnia* bioassay showed a chronic toxic effect only at dilution levels eight times the "worst case" dilution level of 200:1. River water taken below Champion seemed to stimulate *Ceriodaphnia* reproduction. Significant differences in growth of rainbow trout were observed in different wastewater dilutions, but no relationship to the amount of dilution was evident. At this time, the findings of the fish egg bioassay must be considered circumstantial. More water quality information and an expanded monitoring plan are required for determining the impact of Champion on trout egg survival and trout fry development.

Algae/Aquatic Plants

Periphyton Production

A stream's ability to grow plant and animal matter--it's productivity--is influenced by many factors, the foremost being nutrient concentrations. The amounts of the key plant nutrients (notably nitrogen and phosphorus) in the water generally determine how much algae a stream can produce.

Algae use nutrients, carbon dioxide and solar energy to generate additional plant matter or "biomass" via photosynthesis, much the same way grasses do in terrestrial ecosystems. Like the grasses, algae are the

first link in the food chain, (also known as the primary producers), on which grazing animals, and ultimately the top carnivores, are dependent. While the productivity of a fishery is directly related to the level of primary production in a stream, it is possible to have too much of a good thing. Heavy growths of algae in response to elevated nutrient levels from natural or cultural sources can be harmful to desirable fish species, in addition to being aesthetically displeasing.

In the free-flowing reaches of the Clark Fork, the attached bottom-dwelling (benthic) algae, collectively called periphyton, are responsible for essentially all of the primary production. From the standpoint of periphyton growth potential, the Clark Fork is one of the most productive streams in Montana west of the Continental Divide (Bahls et al. 1979).

The productive potential of the Clark Fork in the vicinity of Champion International can be determined from several sources of data collected during the course of this study.

Concentrations of nitrogen and phosphorus measured in the Clark Fork, in point source discharges and tributaries, are discussed in the Nutrients Section as they relate to factors limiting periphyton production and the potential for nuisance algal growths.

Results of algal assays conducted by EPA (Greene et. al. 1985) classified the Clark Fork at Harper Bridge and Huson as being moderately high in productivity. Of the nine sites tested, six were in the moderately high classification. Two of these were above Champion International. (See Data Report, Volume 2).

Results of a riffle community metabolism study conducted by the University of Montana (Kicklighter and Stanford 1985) suggested little difference in primary productivity between Harper Bridge and Huson from November 1984 through August 1985 (See Data Report Volume 2).

Primary productivity in the Clark Fork was also measured as the rate of periphyton growth on artificial substrate surfaces placed on the stream bottom (see Data Report, Volume 1 Appendices). Accrual rates were determined for chlorophyll _a_, the primary photosynthetic pigment in algae, and biomass. The autotrophic[9] index (AI) was calculated as the mass ratio of biomass to chlorophyll _a_.

Based on the assumption that chlorophyll _a_ contributes from one to two percent of algal biomass, AI values of 50 to 100 would be expected in pure algal cultures. Normal AI values for periphyton in unpolluted streams range from 50 to 200, with higher values indicating an increase in relative numbers of non-autotrophic consumer organisms, such as bacteria, that do well in stressed or polluted conditions (A.P.H.A. 1981).

Artificial substrate periphyton samples were collected from the Clark Fork at Harper Bridge and at Huson during October 1983, some five to six

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9 Organisms, including algae and higher plants, that are capable of using inorganic materials in the synthesis of living matter are referred to as being autotrophic.

months before issuance of the current discharge permit to Champion International and again during July and August 1984, approximately four months after Champion began discharging under the current permit from DHES.

Results for chlorophyll a, biomass, autotrophic index, and related parameters for the 1983 and 1984 sample periods can be found in Data Report, Volume 1.

Mean values for chlorophyll a accrual, biomass accrual and autotrophic index at Harper Bridge and Huson for the 1983 and 1984 sample periods are compared in Figure 21. Chlorophyll a and biomass accrual values for the 1983 period are much greater at both Harper Bridge and Huson than those measured in 1984. This difference can probably be attributed to seasonal factors, such as light intensity, temperature and streamflow, which become unfavorable for the growth of certain periphyton organisms during the peak of the summer. Lower autotrophic index values for October 1983 indicate less stressful conditions at both stations.

Statistically, there was no significant difference ($p > .05$)[10] between Harper Bridge and Huson during the 1983 sample period for chlorophyll a accrual, biomass accrual and autotrophic index.

During the 1984 sample period, the only statistically significant difference ($p < .05$) between Harper Bridge and Huson was in chlorophyll a accrual, which was slightly higher at Harper Bridge.

Before the issuance of the current permit, periphyton production at Harper Bridge and Huson, above Champion and below the established mixing zone, respectively, was very similar.

Several months after Champion began discharging under the current permit, mean biomass production was still very similar between Harper Bridge and Huson. The difference in chlorophyll a accrual between the sites, although statistically significant ($p < .05$), was small. Autotrophic index values were very similar, indicating that primary producers (autotrophs) were as important below Champion as above. Mean AI values at both sites were within the 50 to 200 range considered normal for unpolluted streams (A.P.H.A. 1981).

Summary

Periphyton production in the reach of Clark Fork River between Missoula and Huson was higher than in any other reach studied. This was primarily in response to the higher concentrations of nutrients entering the river from the City of Missoula wastewater treatment facility and from the Champion International wastewater treatment ponds.

The levels of periphyton production at Harper Bridge and Huson were found to be very similar. The wastewater entering the Clark Fork from Champion neither caused a detectable increase in periphyton production below that point, nor did it appear to diminish or stress primary production in that reach.

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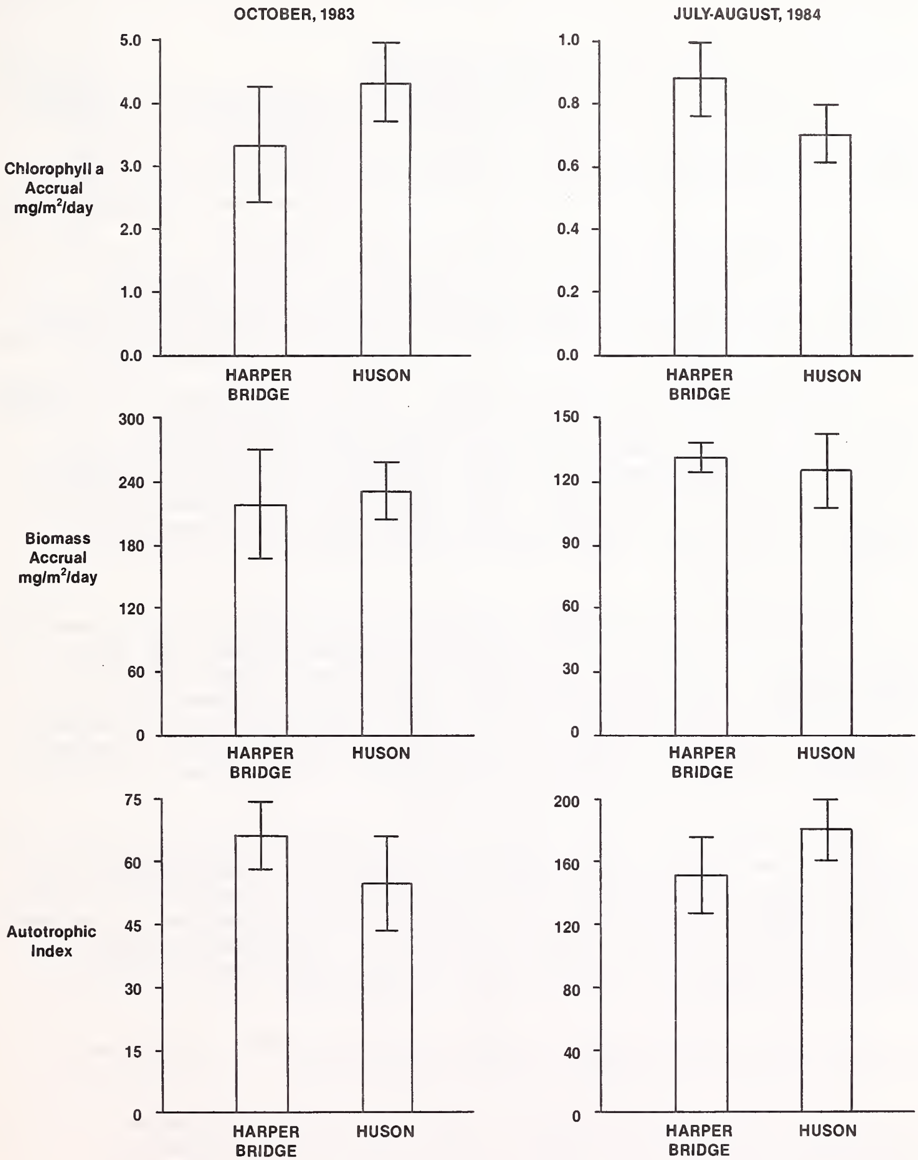
10 The probability is greater than five percent that the difference is due to chance alone.

Figure 21. **Mean values for chlorophyll a accrual, biomass accrual, and autotrophic index for periphyton collected on artificial substrates at Harper Bridge and Huson. Thin bars represent mean ± one standard deviation.**



It is likely that the periphyton community in the Clark Fork between Missoula and Huson has adapted to the elevated concentrations of nutrients present in that reach, and has adequate assimilative capacity to handle minor fluctuations in nutrient loads. Based on the existing data, it appears likely that there will be neither nuisance algal "blooms" nor deleterious effects on primary production in the reach of Clark Fork below Champion if the current permit is extended.

Periphyton Community Structure and Composition

The Clark Fork River and its tributaries in the vicinity of Champion International support a diverse community of periphyton. The types of algae included are single-celled, colonial and filamentous. They are generally microscopic although some forms are visible to the unaided eye. They belong to the green, blue-green, red and golden-brown algal divisions.

While filamentous algae are often the most conspicuous forms on the stream bottom, it is the microscopic golden-brown diatom algae that dominates the periphyton in the Clark Fork system. Often referred to as "slime", diatom algae can blanket much of the stream bottom with a brown, mucilaginous (gelatinous-like) film during periods of optimum growth.

Diatoms possess cell walls of silica. The various species are readily identifiable due to their distinctive shapes and ornamentation. Considerable research has been directed at identifying the environmental preferences of diatom species and the response of the diatom community to pollution and disturbance (Lowe, 1974; Bahls, 1979; Lange-Bertalot, 1979). For these reasons, the structure and composition of the stream diatom community can be used to characterize water quality and to indicate environmental change.

The diversity of the diatom community is one measure of water quality. Bahls (1979) found that in most unpolluted Montana streams, the Shannon diversity index (the greater the diversity, the more unpolluted the sample)(Weber, 1973) lies between three and four, and between 25 and 40 diatom species are identified for every 300 to 400 diatom cells counted. In streams polluted with large concentrations of heavy metals or municipal wastewater, the diatom diversity was depressed to between two and three, and between 20 and 30 species were counted.

Diatoms were also used by Lange-Bertalot (1979) to assess pollution in European rivers that received oxygen-consuming wastes from municipal and industrial sources. Based on his extensive studies, Lange-Bertalot placed over 100 common diatom species of world-wide distribution into one of three groups according to each species sensitivity or tolerance to organic pollution. Sensitivity and tolerance were based on a species' relative abundance at different levels of five-day BOD and DO.

The relationship between the abundance of sensitive diatoms and different levels of pollution is shown in Table 10.

More tolerant diatoms occur in, but do not dominate, diatom associations in unpolluted waters. They increase in abundance at intermediate levels of pollution, but do poorly in waters that are excessively polluted.

Table 10. Abundance of pollution sensitive diatoms and criteria for corresponding pollution levels. After Lange-Bertalot (1979).

Abundance of Sensitive Diatoms (percent)	BOD (mgO_2/liter)	Dissolved Oxygen Saturation Deficit (percent)	Pollution Level
Dominant	< 4	< 30	Moderate
Not Dominant but > 10	< 7	< 50	Critical
< 10	< 13	< 75	Heavy
Nearly Absent	< 22	< 90	Very Heavy
Absent	> 22	> 90	Excessive

The most tolerant diatoms, although usually present in small numbers at low pollution levels, proliferate in excessively polluted waters.

The methods of collection and analysis of periphyton samples, and preparation and analysis of the diatom algae, are described in Data Report, Volume 1, Appendices.

The numbers of diatom species, Shannon diversity values, percent of diatom cells representing species in the Lange-Bertalot pollution indicator groups and major diatom species from 20 sampling sites on the Clark Fork and major tributaries for each of four sampling periods are listed in Data Report, Volume 1.

Ranges and mean values of the number of diatom species and Shannon diversity (d), determined from three data sets collected after issuance of the current Champion discharge permit,[11] are presented in Figure 22 for selected sites on the Clark Fork River.

The mean number of diatom species and mean Shannon diversity increased significantly in the reach from Milltown Dam to above Missoula's wastewater treatment plant over values at Turah. This probably reflects the infusion of higher quality water from the Blackfoot River above Milltown Dam.

Below Missoula's wastewater discharge, mean values decreased sharply, indicating a decline in water quality. Mean number of diatom species and diversity at Harper Bridge were lower than at Turah. The addition of the Bitterroot River did not appear to have a positive influence on numbers or diversity.

At Huson, below Champion International's discharge, the mean number of species was unchanged from that at Harper Bridge, while diversity increased slightly.

At Lozeau, 40 miles below Huson, mean diatom diversity increased considerably and remained at that level to Plains, approximately 100 miles below Huson.

Although the number of diatom species and diatom diversity fluctuated considerably between Turah and Lozeau, mean values (Figure 22) all fell between 25 and 40 for number of species and between three and four for Shannon diversity. Similar ranges were found by Bahls (1979) in Montana streams he considered to be unpolluted.

Mean values for the percent of diatom cells in each of the Lange-Bertalot indicator groups, determined from three data sets collected after issuance of the current Champion International discharge permit, are presented in Figure 23 for selected sites on the Clark Fork and major tributaries.

Pollution sensitive species dominated the diatom communities at all Clark Fork and tributary sites, with the exception of below the Missoula WWTP. There the most tolerant and more tolerant diatom species dominated

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11 The sampling dates for the data sets were: July 31 to August 3, 1984; October 30 to November 2, 1984; and March 18-21, 1985.

Figure 22. Ranges and mean values for the number of diatom species and Shannon diversity ($\bar{d}$) at selected stations on the Clark Fork River from three data sets collected between July, 1984 and March, 1985.

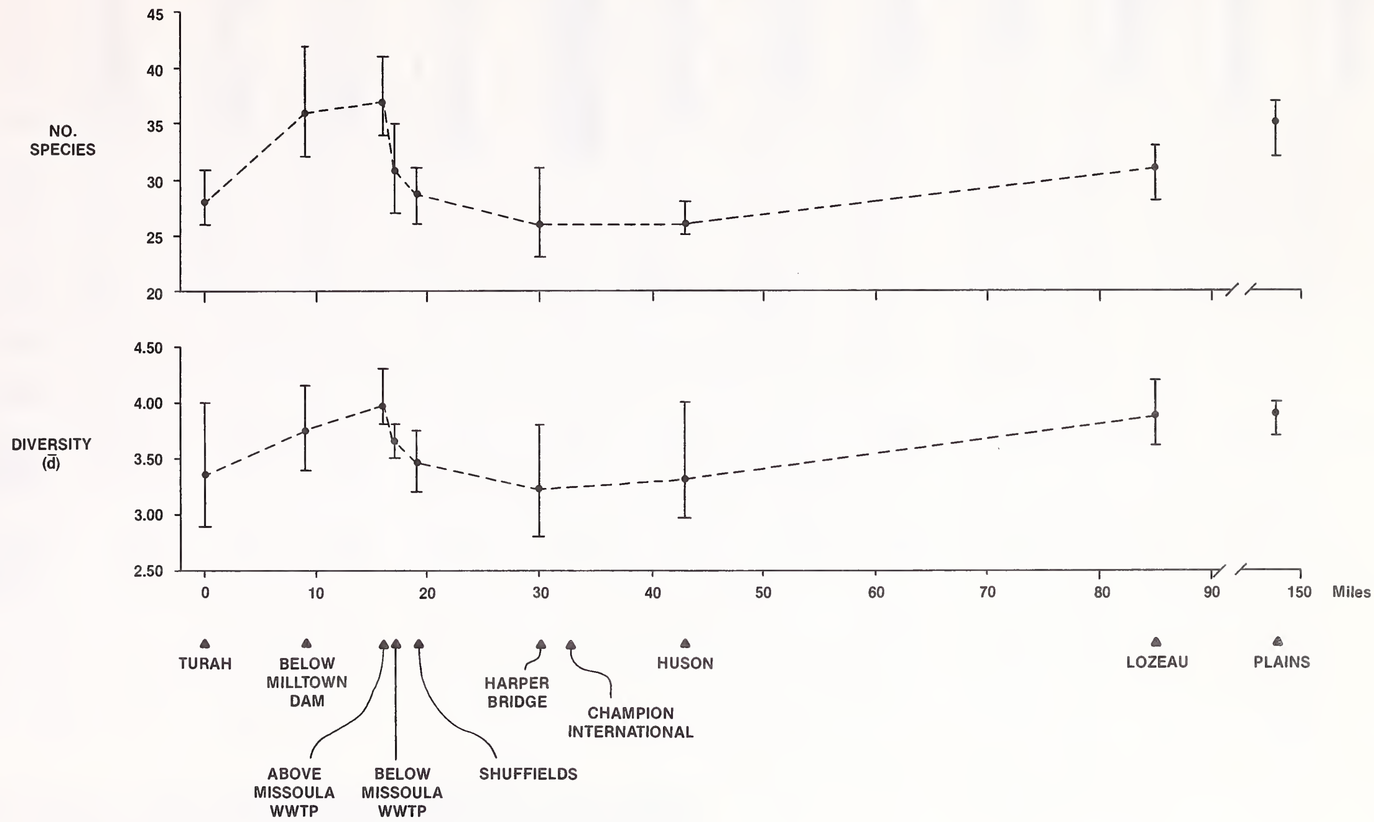
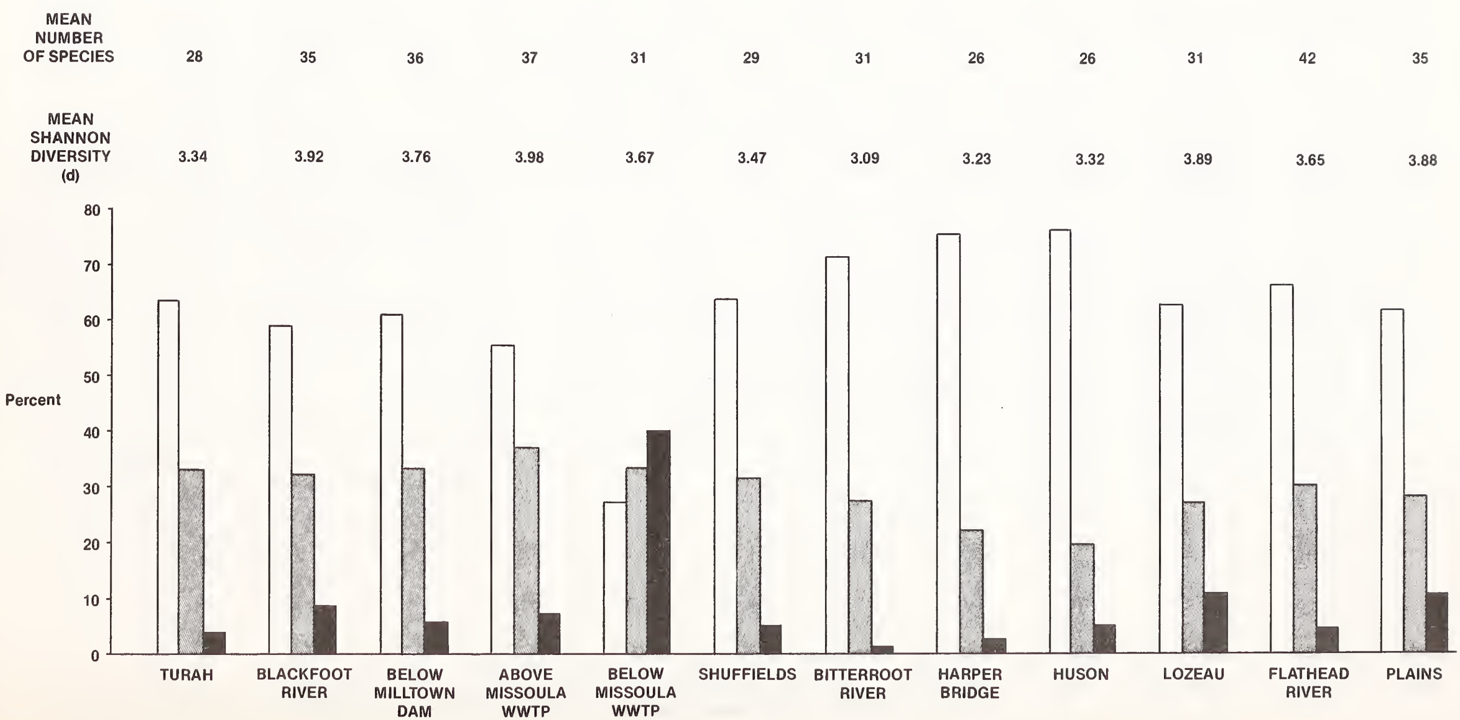


Figure 23. Mean percent of diatom cells in each of three pollution indicator groups for selected stations on the Clark Fork and major tributaries from three data sets collected between July 1984 and March 1985: White columns—sensitive species; shaded columns—more tolerant; black columns—most tolerant.



the sensitive species in mean percent of cells present. This condition, apparently a response to elevated BOD concentrations in the municipal wastewater, was very limited in extent. At Shuffields, approximately two miles downstream, pollution sensitive species were again dominant.

The mean percent of diatom cells in the three indicator groups at Huson, below Champion International, were nearly identical to those at Harper Bridge.

The spring 1984 and 1985 indicator group data from Harper Bridge and Huson, collected just before and one year after issuance of the current discharge permit, are compared in Figure 24. Differences between the two sites were more pronounced in 1984 than in 1985. The percentages of diatom cells in each of the three groups in the spring of 1985 were very similar between Harper Bridge and Huson, and sensitive species exhibited a strong dominance.

According to the scheme of Lange-Bertalot (1979), summarized in Table 10, the pollution level at all Clark Fork and tributary sites, with the exception of immediately below the Missoula wastewater discharge, was "moderate" from the standpoint of oxygen-consuming wastes. This is the lowest level of pollution assigned by this scheme. Pollution was at the "critical" level immediately below the Missoula wastewater outfall. While the dominance of sensitive diatom species quickly rebounded below the "critical" zone, mean diversity continued to decrease at least as far downstream as Harper Bridge. The lowest mean diatom diversity values, at Harper Bridge and Huson, corresponded to the highest mean percent of sensitive diatom species. This suggests that the diatom communities were under stress, but from pollutants other than the organic wastes. Bahls and Weber (in press) found low diversity values for Clark Fork diatom communities dominated by sensitive species, which they attributed to enrichment by inorganic nutrients. This is a plausible explanation for the depressed diversity values below Missoula, since the city's wastewater treatment plant was the major source of inorganic nutrients in the study reach. The sizeable contribution of inorganic nutrients from the Champion International wastewater discharge did not appear to further depress diatom diversity, and in fact, recovery to levels comparable to those seen above Missoula may have already begun at Huson.

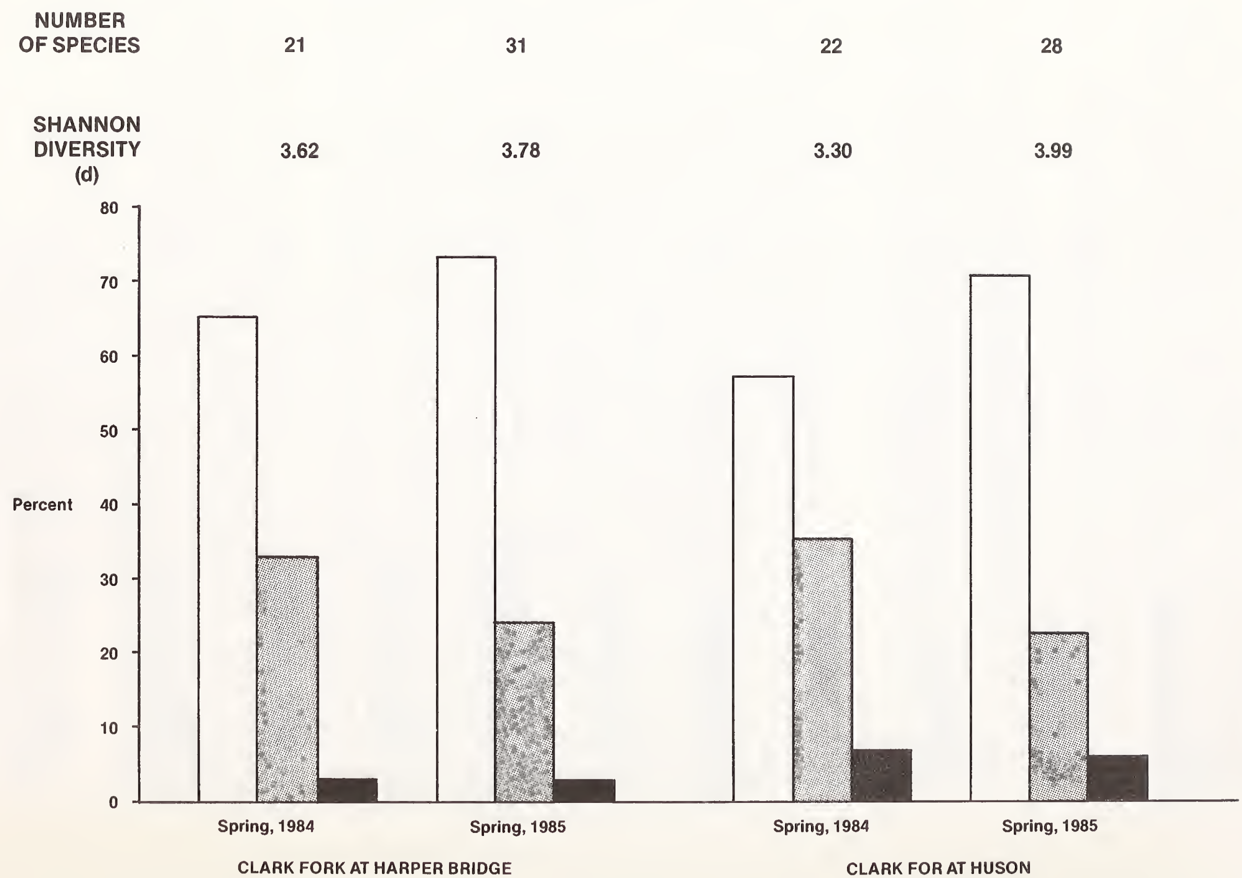
The continued disposal of treated wastewater from Champion International to the Clark Fork River, under the terms of the current discharge permit, should have little, if any, adverse impact on the diatom community and the periphyton as a whole. The periphyton community structure and composition, while somewhat stressed at Harper Bridge, does not exhibit evidence of additional stress or adverse impacts at Huson, below Champion's discharge.

The Aquatic Macroinvertebrate Community

Definition and Use as Water Quality Indicators

Aquatic macroinvertebrates are animals large enough to be seen, can be retained by a U.S. Standard No. 30 sieve and live at least part of their life on or in stream bottoms (Weber, 1983). The major freshwater invertebrate groups are the insects, annelids, molluscs, flatworms,

Figure 24. **Diatom species diversty values and percent of diatom cells in each of three pollution indicator groups at Harper Bridge and Huson, Spring, 1984 and Spring, 1985: white columns—sensitive species; shaded columns—more tolerant species; black columns—most tolerant species.**



roundworms and crustaceans. They may be omnivores, carnivores or herbivores, detritus feeders, parasites, scavengers, grazers or predators. The macroinvertebrate community comprises the food and energy link between algae and fish.

Individual species within the macroinvertebrate community have specific environmental requirements and pollution tolerances just like algae and fish, thus they may also be used to detect stress from pollutants. Because of the relatively long life spans of most macroinvertebrates (up to three years), they reflect water quality conditions over a considerable period of time. Intermittent or infrequent pollutant discharges could easily escape detection by periodic chemical sampling, but they may leave behind tell-tale changes in the makeup of a stream's macroinvertebrate community.

A number of macroinvertebrate species are sensitive to environmental disturbances and contaminants. Toxic substances and suspended solids tend to reduce the number of species and organisms (total abundance or standing crop) in a macroinvertebrate community. Inorganic nutrients generally have little effect on the number of species, but tend to increase the standing crop (Weber, 1973).

Community diversity, as expressed by Shannon's index, is best suited for the detection of stress created by organic wastes. Inorganic suspended and settleable solids, inorganic nutrients and toxic water pollutants have varying effects on community diversity.

Percent similarity is a statistic which measures the degree to which two macroinvertebrate communities are alike in terms of species composition. By comparing similarity values between samples from the same site with those computed for samples from different sites, judgments can be made regarding the extent of disruption to the community caused by the introduction of any kind of pollutant.

Community Structure and Composition of Benthic Macroinvertebrates in the Clark Fork River

During the 1984-1985 water quality study of the Clark Fork River, more than 300 benthic macroinvertebrate samples were collected at 19 stations and analyzed for species composition and numbers. Those data and key statistics are tabulated in Volume I of the Lower Clark Fork Water Quality Monitoring Data Report. An interpretive report of the findings prepared by C.E.Hornig is included in Volume II of that report. The following discussion contains excerpts from the Hornig report.

The lower Clark Fork basin from Missoula to the Idaho border supports a rich macroinvertebrate fauna. More than 200 species were identified, with as many as 60 different species present at one time at individual sampling stations. Diversity values ranged well over 4.0, indicating a fairly healthy, not heavily stressed environment at all study sites.

Several factors contribute to the difficulty of interpreting the diversity values, however. First, western Montana is known to support one of the most diverse aquatic insect faunas in North American. The values obtained in the present study may or may not be unusually high for this

area. Second, the comparison of diversity values obtained in one study with those obtained in others is very difficult. Taxonomic identifications in particular, may vary greatly in precision and scope. Third, some work has shown that high diversity values may be more indicative of a disturbed than of a pristine ecosystem. The main inference that can be drawn from the diversity values obtained for the Clark Fork, then, is that the river is not severely degraded. Lesser impacts cannot be ruled out.

Similarity between sites was often high throughout long segments of the Clark Fork, indicating a high degree of faunal consistency.

The presence of large numbers of non-dipteran (diptera are true flies possessing two wings) aquatic insects, such as mayflies, also indicates a stream not heavily stressed by pollutants. However, the high abundance of insects that are relatively tolerant of pollution and the low diversity (for this part of North America) of the pollution-sensitive stoneflies suggest a stream that has undergone some degree of degradation.

Abundance data at all stations downstream to the Flathead River confluence are comparable to data for the Blackfoot River, ranging from one to several thousand individuals collected per site. Since the invertebrate density of the Blackfoot supports a good trout fishery, it is likely that fish food availability is not a limiting factor for Clark Fork trout populations.

Effects of the City of Missoula Wastewater Treatment Plant (WWTP) and Champion Discharges

Missoula WWTP

Examination of the data for stations just upstream from the Missoula WWTP, immediately below in the plume of the discharge and about two miles below (where mixing is complete), reveals a similar macroinvertebrate community throughout. This is indicated by high between-site similarity coefficients, summarized in Table 11 below:

Table 11. Similarity coefficient values* for paired stations above and below the Missoula WWTP discharge.

	Clark Fork Immediately Above to Just Below WWTP Discharge	Clark Fork Immediately Above to 2 Miles Below WWTP Discharge
Spring 1984	66	65
Summer 1984	57	67
Fall 1984	65	80
Spring 1985	63	57
Summer 1985	75	68
Average	65	67

*Within-site (between-replicate) similarities for this study generally fell in or near the 70's. Thus, between-site values in the 60's can be considered quite high, whereas values below 40 suggest substantial differences in the fauna.

Similarly, the diversity values for the the three stations do not indicate a significant reduction in community diversity attributable to the WWTP discharge as shown in Table 12:

Table 12. Diversity values* for stations above and below the Missoula WWTP discharge.

	Clark Fork Immediately Above WWTP Discharge	Clark Fork Just Below WWTP WWTP Discharge	Clark Fork Two Miles Below WWTP Discharge
Spring 1984	3.81	3.55	3.48
Summer 1984	4.05	3.99	4.32
Fall 1984	3.13	3.53	3.41
Spring 1985	3.9	3.8	3.91
Summer 1985	4.01	3.97	4.49
Average	3.78	3.77	3.92

*Values in the 3.0 - 4.0 range indicate a fairly healthy, not heavily stressed environment.

Worst Case Scenario

The summer 1985 macroinvertebrate sample data should reflect the worst case instream effects of the WWTP discharge during the study period because: 1) low water level tended to maximize the impact of the wastewater due to less dilution, higher water temperatures and, possibly, increased settling of solid materials and 2) operational problems occurred sporadically at the WWTP in spring and summer 1985 resulting in some pollutants exceeding discharge permit limitations.

Despite the expected stress, the macroinvertebrate community remained similar from above to below the discharge, as seen in the similarity coefficients and diversities in the previous Tables. Of note were significant differences in the amount and type of periphyton above and below the discharge. Coverage was relatively sparse above, extremely heavy just below and intermediate two miles below. These differences in the abundance of periphyton, which serves as food source to many stream insects, was very likely a contributing factor in the doubling in total abundance (numbers) of macroinvertebrates at the station just below the discharge. Total abundance at the further downstream station was intermediate to the other two. Several non-dominant species seemed to respond positively or negatively to these observed differences in periphyton type and abundance. In conclusion, even during the summer 1985 low water period, the macroinvertebrate community structure failed to respond more than subtly to the WWTP discharge.

Champion Frenchtown Mill

Examination of the data for one station above (Harper Bridge) and three stations below (Marcure, Frenchtown and Huson--0.5, four and eight miles downstream of the discharge, respectively) the Champion wastewater discharge does not generally reveal significant differences in macroinvertebrate community structure. Average percentage similarity between Harper Bridge and Huson (where mixing of wastewater is complete) is high, indicating similar communities at both sites. The Marcure and Frenchtown stations are in areas exposed to high concentrations of Champion pond seepage and an incompletely mixed discharged wastewater. The average percentage similarity values between these stations and the Harper Bridge site show larger dissimilarities in macroinvertebrate community composition than the Huson site, but the differences are not great, considering that the stations are located in the waste mixing zone. This apparent limited and localized impact in the mixing zone below Champion is generally supported by the Institute of Paper Chemistry's (IPC) annual invertebrate surveys of the Clark Fork River (IPC, 1985, 1984, 1983).

Table 13 summarizes this data:

Table 13. Similarity coefficient values* for paired stations above and below the Champion Frenchtown Mill wastewater discharge.

	Clark Fork Immediately Above To 0.5 Miles Below Champion Discharge	Clark Fork Immediately Above to 4 miles Below Champion Discharge	Clark Fork Immediately Above to 8 miles Below Champion Discharge
Spring 1984	72	**	69
Summer 1984	43	58	77
Fall 1984	49	70	87
Spring 1985	64	63	59
Summer 1985	61	41	54
Average	58	58	69

* Within-site (between-replicate) similarities for this study generally in or near the 70's. Thus, between-site values in the 60's can be considered quite high, whereas values below 40 suggest substantial differences in the fauna.

** This sampling station not yet established in spring 1984.

Average diversity values for each of the four sites are essentially the same and are comparable to those measured above and below the Missoula WWTP (Table 14.)

Table 14. Diversity values* for stations above and below the Champion Frenchtown Mill wastewater discharge.

	Clark Fork Immediately Above Champion Discharge	Clark Fork 0.5 Miles Below Champion Discharge	Clark Fork 4 Miles Below Champion Discharge	Clark Fork 8 Miles Below Champion Discharge
Spring 1984	3.71	3.95	**	3.28
Summer 1984	4.0	3.36	3.62	3.74
Fall 1984	3.22	2.49	3.09	2.93
Spring 1985	3.6	3.81	3.69	3.48
Summer 1985	3.91	4.58	4.51	4.67
Average	3.69	3.64	3.73	3.62

* Values in the 4.0 range indicate a fairly healthy, not heavily stressed environment.
** This sampling station not yet established in spring 1984.

Worst Case Scenario

An examination of the individual data presented in Tables 13 and 14 reveals significant changes in community similarity and diversity occurring downstream from the Champion facility in fall 1984 and possibly to a slight extent in summer 1984. Diversity values show a sharp drop at the Marcure site 0.5 miles below the Champion discharge followed by a gradual recovery. Several species in the fall collections followed a classic impact/recovery pattern with significant reductions at Marcure followed by gradual increases through the Frenchtown and Huson sites. Although stream temperatures were not unusually high nor were streamflows out of the ordinary for the time of year, Champion's average wastewater discharge rate was substantial in September through November 1984. Suspended solids loading averaged more than 2,200 lbs/day with a river to wastewater dilution ratio of about 624 to 1. The apparent impact on the macroinvertebrate community structure in the mixing zone can be classified as subtle and does not approach those often found downstream from major pollution outfalls. Hornig recommends further examination of the possibility of impact from the mill effluent during the fall season and recommends careful future monitoring of the several seemingly responsive species.

Effects of the Proposed Action

During the 1984-1985 water quality study, Champion did not discharge wastewater to the full extent of the permit limits; only about half the allowable maximum annual load of four million pounds of TSS were released to the river. Thus, in order to address the maximum potential impacts to the Clark Fork's macroinvertebrate community which could occur, the consequences of increased suspended solids loading must be considered.

An examination of river color data for fall 1984 indicates that the concentration of Champion wastewater in the Clark Fork at the Marcure monitoring site (the site where a significant impact was documented) may

have been about twice that present in the river at Huson (color 17.0 SCU at Marcure vs. 8.5 at Huson). This was due to an incomplete mixing of the surface discharge and the presence of pond seepage zones at the sampling location. Under a doubling of the annual suspended solids loading rate, it is reasonable to assume that an impact comparable to that seen at Marcure might occur at Huson, at the end of the mixing zone. However, during the fall 1984 sampling, the color increase from Harper Bridge to Huson was 4.9 SCU, very near to the maximum five unit increase allowed under the discharge permit. Thus, permit limitations governing river quality would have prevented any greater surface discharge than that which was occurring during that time. Most of any increased suspended solids loading would have to occur during the period April to July (85 percent of the total annual load in 1984-1985 was discharged during that period). Since river flow rates and the background suspended solids load are then at their annual peak, documentation of any increased impact to the macroinvertebrate community would not be likely.

Presently, the WQB is scheduled to conduct macroinvertebrate surveys of the Clark Fork at least once a year in 1986 and 1987 at 30 stations from the headwaters to below Cabinet Gorge Dam. Additionally, the IPC summer samplings, which are funded by Champion, will continue indefinitely. With the baseline macroinvertebrate data that now exist (WQB 1984-1985 data, nearly continuous IPC data 1956-present) future monitoring will allow evaluations of the effects of the Champion discharge under varying annual loading rates, and reveal any cumulative impacts which may result from a year around discharge. A condition in Champion's discharge permit requires that if river data show a violation of water quality standards, the permit will be modified to ensure compliance. The documentation of significant impacts within the macroinvertebrate community below the mixing zone due to increased suspended solids loading would constitute a violation of water quality standards.

Aesthetics

Definition

"Aesthetics is defined as the branch of philosophy that provides a theory of the beautiful. Although perceptions of many forms of beauty are profoundly subjective and experienced differently by each individual, there is an apparent sameness in the human response to the beauties of water." (National Academy of Sciences (NAS), 1973).

In order to fulfill Congress's intent of attaining swimmable, fishable surface waters, regulatory agencies must preserve or improve the aesthetic qualities of the nation's lakes, rivers and streams.

According to published criteria, surface waters will be aesthetically pleasing if they are free of the following:

1. Materials that will settle to form objectionable deposits;

2. Floating debris, oil, scum and other matter;

3. Substances producing objectionable color, odor, taste or turbidity;

4. Substances that injure or are toxic or produce adverse physiological responses in humans, animals or plants, and

5. Substances and conditions or combinations thereof in concentrations which produce undesirable aquatic life (USEPA 1977; NAS 1973).

An additional category has been proposed:

6. Freedom from substances attributable to wastewater or other discharges in amounts that would interfere with the existence of life forms of aesthetic value (American Fisheries Society (AFS), 1979).

Accordingly, most industrial and municipal wastewater discharge permits administered under Montana's MPDES program include statements which read: "There shall be no discharge of floating solids or visible foam in other than trace amounts." Limitations on other parameters which may affect the aesthetic qualities of the receiving water, such as suspended solids, turbidity, color, oil and grease, and toxic substances are required as appropriate (considering the nature of a particular discharge), and monitoring for those variables is required.

Aesthetics Problems in the Clark Fork River

During the public review of the proposed modification to Champion's discharge permit in 1984, many people expressed concern over perceived aesthetics problems in the Clark Fork downstream from Champion's wastewater discharge. Complaints included an apparent increase in river foam, reports of a dirty film on the water, the presence of a whitish residue on river cobbles after high water subsided, foul-smelling water and catches of off-flavor fish. Similar complaints have been received since then, including protests from people who observed problems upstream from Champion and in the lower Bitterroot River area.

Aesthetics monitoring was done during the 18 month study. The investigations involved the following activities:

1. A general field reconnaissance was made to look for evidence of aesthetics problems in the river, particularly: the presence and character of foam, sludge deposits, slime growth, stained rocks, colored or cloudy water, foul-smelling water and surface film.

2. Tests of river and wastewaters were conducted to determine foaming tendency and stability, and a quantitative test was done to determine concentrations of surfactants (foaming agents).

3. An organic analysis was done on Clark Fork, Bitterroot River and Champion wastewater foam samples to determine if the presence of unique compounds could link downstream foam accumulations to the Champion wastewater discharge.

4. Numerous microscopic examinations were done on solid materials in

the Champion wastewater, suspended and settled solids in the river, residues on shoreline rocks and solids suspended in river foam.

5. River and wastewater color monitoring was carried out.

6. An evaluation for flavor and odor was done on resident game fish downstream from the Champion discharge and on hatchery trout exposed to varying concentrations of Champion effluent.

The findings included:

1. Aesthetics Reconnaissance - Field personnel observed no sludge deposits, slime growths or foul-smelling water attributable to the Champion discharge or subsurface seepage during the study period. Stained rocks and colored water were evident in localized areas of pond seepage within the mixing zone. Also, the area from the Champion discharge to well below the extent of the mixing zone consistently appeared to be carrying a higher concentration of an organic floc-like material. River monitoring results for organic suspended solids (VSS) generally support this observation.

The presence of considerable quantities of surface foam on the river below Champion's discharge--especially in backwater areas--was deemed as the most significant factor reducing aesthetic appeal in the lower river. The problem was particularly evident in the fall and early spring when water temperatures were in the range of four to seven degrees C. Surface foam and backwater accumulations were also frequently observed in the Clark Fork above the Champion discharge and in the Bitterroot near its mouth. However, the quantity below Champion was consistently greater and the character different, in that it was loftier, in larger masses and had a dirtier appearance. Since the kraft pulping process generates wastewater that contains compounds which are known foaming agents (ncasi, 1983), it is probable the Champion discharge contributed to the situation. Any agents discharged would cause foam to appear below riffles and rapids where aeration occurs. Foam was not observed in the Champion wastestream at the time of discharge.

2. Foaming Tendency, Stability and Quantitative Foaming Agent Test - The foaming tendency and stability tests were positive only when the sample was 100 percent Champion effluent. The various river water samples and the Missoula WWTP effluent failed to produce foam under laboratory conditions. Wastewater interferences were encountered in the foaming agent test and those results were inconclusive.

3. River and Wastewater Foam Organic Analyses - These results are expected to shed some light onto the possible connection between the Champion wastewater discharge and the documented river foam problem in the Clark Fork. Unfortunately the analyses by the EPA Region VIII laboratory in Denver will not be available until late December 1985.

4. Microscopic Examinations of River Water, Wastewater and Foam Constituent Solids and Shoreline Residues - At least 14 samples of Champion wastewater were examined for solid materials between October 1984 and July 1985. In every case, the material consisted of high concentrations of common, non-pathogenic bacteria and lesser quantities of fungi, algae,

protozoans and fine particulate organic matter (FPOM). Wood fibers were never observed.

Water samples containing the instream organic floc were filtered and the solids examined under the microscope. Samples of this floc which had settled in slack water areas near shore were also obtained from the DFWP and examined in the same manner. The material consisted primarily of diatom algae with lesser quantities of non-descript FPOM.

Solid materials separated from the river and wastewater foam samples were made up of a wide variety of substances. Included were diatoms, unicellular and filamentous algae, insects, insect parts, fungi, bacteria, protozoans, plant fragments, non-descript FPOM and inorganic matter (fine sand, silt and clay particles). Amorphous (without form or structure) masses of FPOM were common in the Champion wastewater foam and more common in the Clark Fork downstream from Champion than above.

Samples of whitish residues from river shore-line rocks were determined to contain dead diatoms and other algae and aluminum silicate, a common product of rock weathering.

5. Color Monitoring - Results of analyses for river color indicate a general compliance with permit limitations (see Color Section in the EIS). The five unit maximum allowable increase in background river color, as specified in Champion's discharge permit, should protect against aesthetic problems below the mixing zone due to increased river color. Relatively high color values were obtained from samples collected in several areas within the mixing zone. However, the DHES discharge permit places no restriction on allowable color in that eight mile reach of the river. These localized areas of tea-colored water generally within a few yards of the river banks and would have reduced the aesthetics for river floaters. Public access via the immediate shoreline is not readily available.

6. Fish Flavor and Odor Evaluations - Two types of tests were performed. The first, involved two to three pound hatchery rainbow trout exposed to varying concentrations of Champion wastewater for 48 hours. The results indicted the following:

In one of two replications of this test, fish exposed to a 1:10 dilution of wastewater to river water were significantly higher in "off-odor," and "off-flavor" and significantly lower in overall desirability than the other treated samples which ranged from 1:50 to 200:1 dilutions. Ironically, samples of the control fish exposed to no wastewater were judged to be not significantly different from the 1:10 sample in off-flavor and overall desirability, although they were significantly lower in off-odor.

A second test was conducted due to the unexpected flavor and desirability rating of the control. Treated samples, the original control and a new control were used. In overall desirability, samples 1:10 and 1:50 were rated the lowest and were not significantly different from each other. The 1:100 and 1:200 samples were rated as most desirable, being more desirable than the new control. The original control was second in overall desirability, but not significantly different than the 1:100 sample. Thus, it is apparent that high concentrations (1:10, 1:50) of the

kraft mill's effluent did increase off-odor and off-flavor of the sample fish and reduced overall desirability. This is consistent with other studies which have shown significant tainting of salmon exposed to 9-12 percent concentrations by volume of treated kraft mill effluent (NAS, 1973). Surprisingly, it seems possible that low levels of the wastewater actually improve the odor and flavor of hatchery-reared rainbow trout. Since the Champion effluent is discharged to the river at a minimum dilution ratio of 1:200, fish flesh tainting in the river seems unlikely, except perhaps in the mixing zone.

The second type of test involving resident river game fish was conducted on mature rainbow trout collected in early October, 1985 from areas above the Champion discharge and within the downstream mixing zone. Although the downstream samples scored slightly higher in off-odor and off-flavor and slightly lower in overall desirability, there were no significant differences at the 95 percent confidence level. It should be noted that Champion does not discharge at its highest rate during the fall nor is wastewater dilution the lowest at that time of year. In fact, Champion had a low average discharge rate throughout the past summer, with no discharge occurring from July 3 to August 11. A higher wastewater discharge rate during and prior to sample collection might have resulted in different test results. The odor and flavor evaluation of resident fish should be repeated during the spring or early summer high discharge period, in view of complaints of off-flavor fish as far downstream as Superior, some 57 river miles below the discharge point.

Effects of the Proposed Action

In view of DHES study results, it seems probable that a year round discharge of wastewater by Champion to the full extent of the permit limits would magnify the documented foam problems in the Clark Fork downstream from the discharge. Since the river foam problem was the most significant factor reducing aesthetics in the Clark Fork during the study period, Champion should investigate and utilize additional effluent foam control practices which are available (ncasi, 1982). Additionally, further study should be done to determine if dissolved organic substances in the surface discharge or pond seepage precipitate instream and contribute to the non-algal organic floc (FPOM) observed in the river downstream of the mill. The water in the eight mile long mixing zone is impacted by color in direct discharge and seepage from Champion's wastewater treatment facility. Montana regulations allow a mixing zone in which water quality standards for color and other parameters do not apply. However, Champion's apparent commitment to overall effluent color reduction and on-going experimentation with color removal methods should result in a long-term reduction in the problem.

Groundwater Impacts

General Hydrogeology

Champion's Frenchtown Mill is situated on the flood plain of the Clark Fork River. Many river channels run through Champion's property (reference the Geology and Soils Section).

The entire area is variable in its geologic character. At the site of the Frenchtown Mill's newer production well field (about 1-1½ miles south of the plant) a number of holes were drilled during the construction of the well field. Based on these drilled holes the entire area near the newer production well field generally consists of 25 to 35 feet of sand, silt and gravel in layers and lenses. Beneath this is 65 to 75 feet of fine sand, silt, and clay with scattered gravel layers. This is underlain by a sand and gravel layer about 45 feet thick containing some silt.

Logs of five older production wells in the vicinity of the plant (Brietkrietz, 1964) show in descending order, a six to nine foot topsoil layer, a gravel and sand layer about 20 feet thick and a 125 to 190 foot thick zone of lenses of sand, silt and clay with some scattered gravel layers. This zone is underlain by 15 to 32 feet of coarse sand and gravel.

Logs of numerous wells both north and south of the plant, show similar geological conditions in the unconsolidated alluvium (Brietkrietz, 1974 and unpublished well logs submitted to the State of Montana). An upper sand and gravel layer is underlain by a thicker zone consisting of layers and mixtures of sand, silt, clay and gravel. Beneath this zone is a layer consisting of coarse sand and gravel. The alluvium is derived from reworking of older glacial debris, lake deposits, and older Tertiary sedimentary deposits from the Missoula Valley area. The alluvium is underlain by bedrock consisting of limestone and argillite of Cambrian or Precambrian age.

The entire thickness of alluvium (about 130 to 170 feet) contains zones that will readily yield water to wells. There are, however, two zones that are widely used as sources of groundwater and almost all wells in the area are completed in one of these two zones.

The upper layer of alluvium (25 to 35 feet deep), typically composed of sand and gravel, is commonly used as a source of groundwater for a number of wells in the area. This zone could be termed an upper aquifer since its presence is reasonably consistent throughout the area and it usually contains moderate to large quantities of water that can be developed with wells. Beneath this upper zone is a relatively thick interval consisting of layers, lenses and mixtures of sand, silt, clay and gravel. A common characteristic of this interval is lower permeability and hence its poor ability to yield water to wells. Few wells are completed in the interval and yields of these wells are not high. This interval varies in thickness throughout the area, but generally is 60 to 125 feet thick.

Beneath this interval is an excellent water-bearing zone, composed of coarse sand and gravel with scattered lenses of silt and clay. This lower zone is a prolific water producer and almost all high capacity wells in the area are completed in this zone including all of the Frenchtown Mill's production wells. Based on numerous well logs, this lower aquifer or zone is present beneath most of the river valley. The zone is consistently encountered in deep wells in the area. Thickness of this aquifer varies from about 20 to 40 feet.

Hydraulically, the upper and lower aquifers appear to be poorly, but definitely connected. Hydraulic testing on the mill's wells indicates the lower aquifer obtains water from the overlying zone and slightly affects

water levels in the upper aquifer. This is not an uncommon hydraulic situation and the mechanism of water transfer from one aquifer to another aquifer is termed "leakage." Observation wells near the mill's production wells also show a poor vertical hydraulic connection in the area. Water levels in deep observation wells respond rapidly to pumpage from the deep aquifer, but shallow observation wells do not show a significant response to pumpage. Available geological and hydraulic data all indicate that there is an upper aquifer separated from a lower aquifer by a less permeable interval.

Recharge to groundwater in the area is from streams, irrigation and precipitation. Not a great deal is known about the areas of recharge. The shallow or upper aquifer probably is recharged primarily by direct precipitation, irrigation and infiltration from drainage systems entering the valley. Groundwater in the shallow aquifer discharges largely to the Clark Fork River. The source of recharge to the lower aquifer is more obscure. Recharge likely comes from streams, irrigation and downward movement from other aquifers. Recharge may occur at some distance from Champion's property. Discharge from the lower aquifer is also poorly known. The aquifer probably discharges to the Clark Fork River at some distance downstream from the Frenchtown Mill.

Groundwater Impacts

Quantity

The pulp mill uses approximately 24.5 million gallons per day from 12 deep wells located in the vicinity of the mill. About 20 percent of the water is produced from four wells at the plant site and the remaining 80 percent comes from eight wells situated about 1.5 miles south of the mill. These production wells cause a localized cone of depression in the groundwater table. The groundwater table at the east property boundary appears to be lowered about three feet by the Champion production wells.

Quality

It is well known that Champion's Frenchtown Mill impacts the quality of shallow groundwater near the plant site. Rapid infiltration and seepage from the mill's wastewater pond system accounted for about 51 percent of the 16.5 mgd of wastewater disposed of between July 1, 1984 and June 30, 1985 (DHES MPDES Champion file). Most of this seepage discharges through the shallow aquifer to the Clark Fork River as evidenced by the color measurements in the river, during times of low or no discharge.

Grimestad (1977) conducted a study of shallow groundwater quality and movement in the area surrounding the Frenchtown Mill. His potentiometric surface water table maps showed that the groundwater mounds somewhat due to rapid infiltration influence but moves generally in a direction toward and parallel to the river. Grimestad recently updated his map of the piezometric surface (Figure 25) and also mapped the specific conductance (Figure 26) of the shallow groundwater in the vicinity of the Frenchtown Mill. The specific conductance map should generally delineate the plume of effluent-contaminated groundwater. From these two maps it can be seen that the plume is moving generally northwestward. Some contamination has moved

Figure 25. Contour map of the potentiometric surface of the shallow aquifer in the vicinity of Champion International's Frenchtown Mill measured between November 6-16, 1985 (Grimestad 1985).

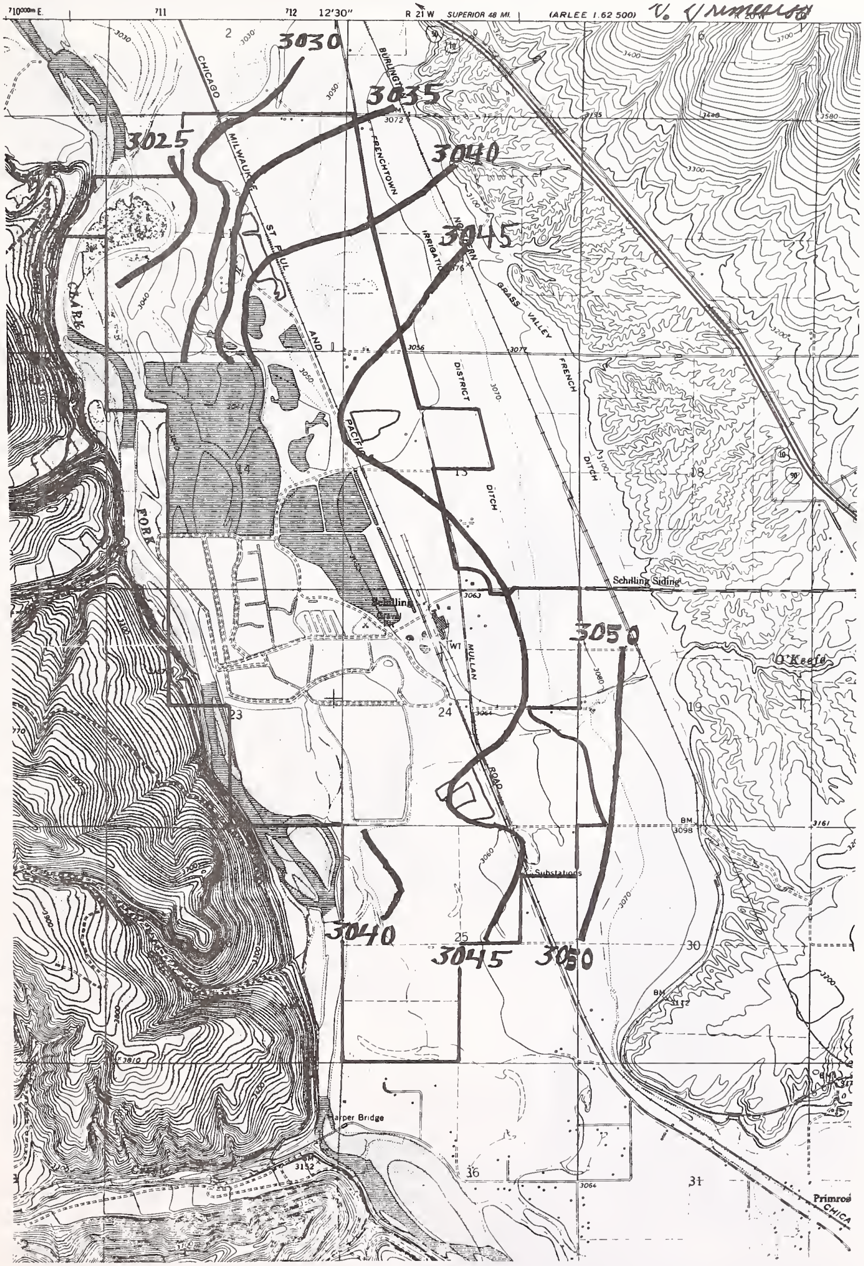
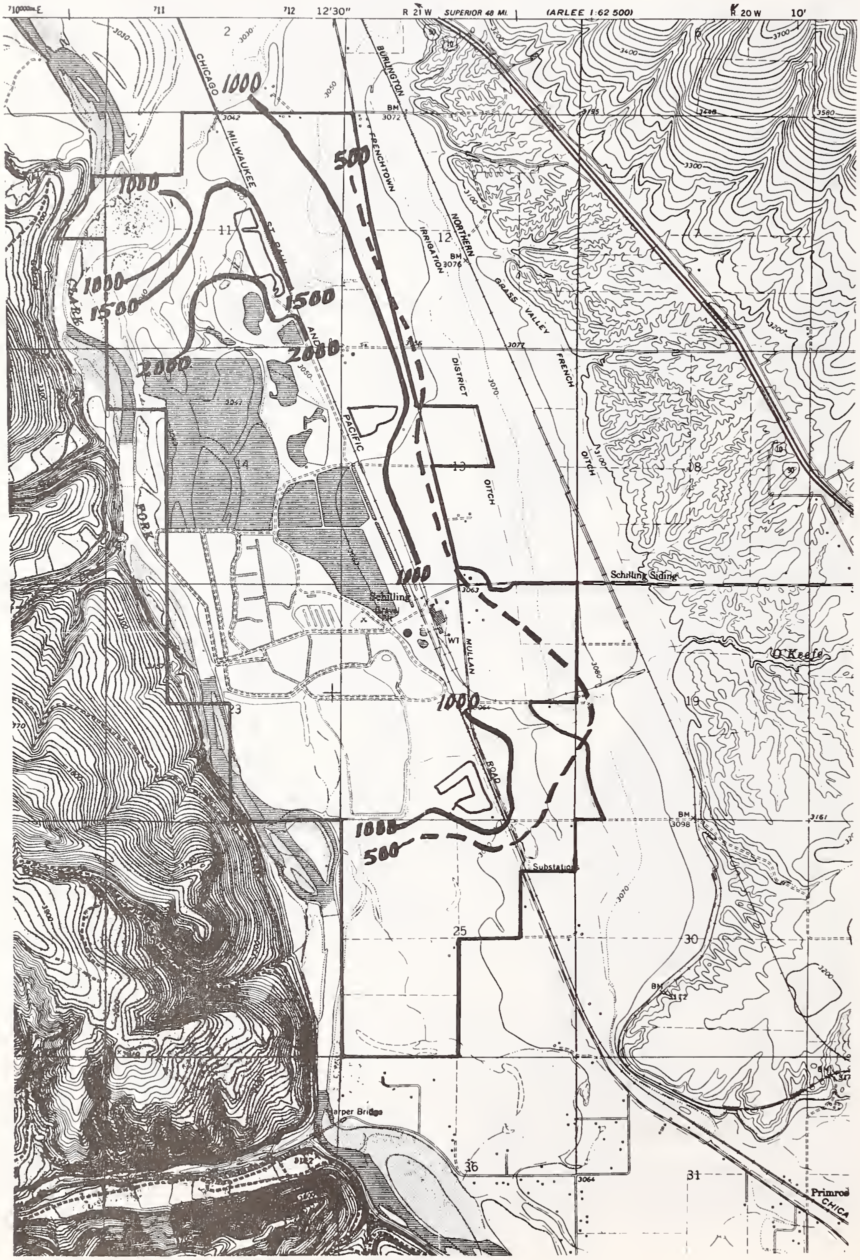


Figure 26. Countour map of the specific conductance (umhos) measured for the shallow aquifer in the vicinity of Champion International's Frenchtown Mill between November 6-16, 1985 (Grimestad 1985).



northwest across the property boundary, but the exact outer extent of the plume is not well defined. Data used by Grimestad in compiling the two maps are shown in Table 15.

Shallow wells recently resampled by Grimestad are shown in Figure 27. The DHES recently sampled some private wells near the edge of Champion's property boundary. These wells are shown on Map 1, along with monitoring wells that Champion has been sampling. Data from the DHES and Champion sampling are shown in Table 16. These data show that some pollution has moved off the property in the shallow aquifer in the general flow direction to the north, and possibly somewhat along the east boundary due to mounding from rapid infiltration. The deeper aquifer has not shown any contamination, according to Champion and DHES deep well sampling.

In summary, studies have shown that groundwater pollution from Champion's effluent appears to be confined to the upper or shallow aquifer, and moves generally north-northwestward towards the river. Some pollution of the shallow aquifer north of the property boundary has occurred, but further study will be required to determine its exact extent.

AESTHETICS

Reference Foam, Slime, Color and Fish Flavor in the Water Section.

AIR QUALITY

The Missoula Valley at the the confluence of the Clark Fork and Bitterroot Rivers and surrounded by mountains, is protected from strong prevailing west winds, thus, during the fall and winter, it is subject to severe temperature inversions. These inversions are persistent, lasting for days or weeks at a time. During these periods, high concentrations of pollutants can be trapped in the valley.

Since the Frenchtown Mill is 15 miles west of Missoula, it is relatively isolated from other air pollution sources.

The air quality in the vicinity of the mill is generally good, with the exception of ambient concentrations of hydrogen sulfide. Hydrogen sulfide levels have exceeded Montana's ambient air quality standard during each of the last five years. The high levels of hydrogen sulfide are responsible for a continuing odor problem. With the exception of particulates, concentrations of all pollutants have remained relatively constant for the past five years.

Sulfates

Missoula County analyzes filters from air monitoring equipment at the Well Field and Railroad Bluff sites near the mill for sulfates. Sulfates are fine particulates usually formed by the chemical oxidation of gaseous sulfur compounds in the atmosphere. Since the Champion mill is a substantial source of hydrogen sulfide, sulfur dioxide, mercaptans (a group of organosulfur compounds derived from hydrogen sulfide), and disulfides, sulfate concentrations serve as an indicator of Champion's impact on total

GARRY GRIMESTAD
CONSULTING HYDROLOGIST
2717 SOUTH HILLS DRIVE
MISSOULA, MONTANA 59803

19 Nov 1985

Mr. Larry Weeks
Technical Director for Mill Operations
Champion International Corporation
Frenchtown Mill
Drawer D
Missoula, Montana 59806

Dear Mr. Weeks:

Here are the results of a water-level and conductivity survey conducted between 06 and 15 November, 1985. Locations and data interpretations are shown on accompanying maps.

Test Wells and Other On-Site Samples
(locations shown on accompanying map)

Well		Water Surface Elevation (feet)	Conductivity (micromhos)
H1		3043.5	2090
H2		3042.9	730
H4		3040.4	1820
H5		3033.9	5100
H6		3030.0	380
H8		3024.2	2400
H9		3031.5	840
H10		3035.0	1300
H11		3038.2	570
H12		3041.7	1200
H13		3025.6	340
H19		3041.4	970
H20		3043.2	560
H21		3043.6	1680
H22		3042.8	850
H25		3040.1	350
H26		3045.9	1060
H27		3045.9	1220
H28		3037.0	140
K1	(15')	3028.3	1280
K2	(20')	3033.8	2310
K3	(50')	3040.0	1040
K4	(15')		2180
	(50')	3039.9	620
K5		3040.9	2000
K6	(?)	3037.2	480
K7	(15')	3032.6	2640

(50′)			340
K8 (15′)	3028.5		1490
K9 (15′)	3024.7		880
K10 (15′)	3037.7		170
K11 (10′)			800
(15′)			1350
(50′)	3028.9		1390
K17 (20′)	3039.7		1020
K19	3036.8		1140
K20	3039.6		1160
K22	3029.7		1200
K23	3042.5		940
K26	3044.5		920
K29	3045.1		440
K30	3045.4		440
K31	3045.3		560
K32	3043.0		405
R2	3032.8		2600
R4	3027.9		2540
R5	3025.9		1020
404	3037.1		2500
421	3029.9		2020
423	3028.6		1660
Gursky Well	3042.9	(T.D. = 109.9 ft.)	240
Danforth Well	3043.1	(T.D. = 23.9 ft.)	200
Slough near K22	------		1390
RI Basin B	------	(ponded mill effluent)	2620
North Polishing Pond	------	(ponded mill effluent)	2610

Domestic Wells / Springs
(locations shown on accompanying map)

Well	Water Surface Elevation (feet)		Conductivity (micromhos)
D. ARNOLD	------	(T.D. = ??)	370
L. BOURKLUND	3046.8	(T.D. = 32 ft.)	420
D. CURTISS	3022.3	(T.D. = 28 ft.)	1400
R. DANFORTH	3047.2	(T.D. = 30 ft.)	350
A. DESCHAMPS	------	(T.D. = 158 ft.)	300
C. FAIRBANK	------	(T.D. = 123 ft.)	470
G. FRANCHUK	3051	(T.D. = 139 ft.)	280
J. HARRISON	3048.6	(T.D. = 110 ft.)	350
H. HELLER	3066	(T.D. = 120 ft.)	270

J. KAMMERER	3064	(T.D. = 100+ ft.)	255
Larry LaCASSE	------	(T.D. = 35 ft.)	470
Leo LaCASSE	------	(T.D. = 146 ft.)	310
H. LaCASSE	(new domestic)		
	3042.0	(T.D. = 127 ft.)	320
	(livestock)		
	------	(T.D. = 32 ft.)	580
D. LUCIER	(domestic)		
	3023 ?	(T.D. = 60 ft.)	590
	(trailer court)		
	------	(T.D. = 60-80 ft.)	580
	(spring in SW-SE-02-14N-21W)		960
	(spring near trailer court)		580
E. MARCURE	------	(T.D. = 162 ft.)	420
R. PETERSEN	(domestic)		
	------	(T.D. = 163 ft.)	350
	(feedlot)		
	------	(T.D. = 161 ft.)	360
D. PUTNAM	------	(T.D. = 135 ft.)	290
G. REYNOLDS	(AKA "Shorty's")		
	3031.8	(T.D. = 163 ft.)	450
F. RUPLE	------	(T.D. = 105 ft.)	300
G. SIEBERS	3041.7	(T.D. = 100+ft.)	310

A number of test wells were not sampled and are therefore not shown above. This is because they were either plugged or have been removed or destroyed.

The record of well-head elevations could not be located at the School of Forestry, so several had to be recomputed indirectly from my records of well-site ground-surface elevations and corresponding heights of casing-tops above ground. Resulting computed water-table elevations should be accurate to within 0.2 feet. This method was used only for those wells which were emplaced after the accompanying 1974 level survey map was completed. Domestic well water levels were computed using ground surface elevations estimated from USGS Topographic maps.

Conductivity was determined using a new ,temperature compensated, Myron L. Company portable dissolved solids meter (model pDS 10) which was calibrated both prior to and after the completion of sampling. Conductivity readings should be accurate to well

within 10 % of the listed values.

INTERPRETATION

Accompanying water-table and conductivity maps were constructed using the above measurements. There are some anomalous readings in both data sets, but I believe the maps are a fairly accurate representation of actual field conditions.

Anomalous conductivity values are apparent at wells H5, K6, and at those wells (such as H13) which are near the cooling water discharge ditch. Water in H5 was at or near the bottom of the well and may have been residual water which became trapped in the well for a time sufficient to permit the development of chemical reactions between the fluid and well casing. H13 is undoubtedly sampling cooling water, but the reason for low conductivity in K6, which is in RI basin B, is unknown.

Garry Grimestad

GARRY GRIMESTAD

Figure 27. Map showing the location of test wells and domestic wells in the vicinity of Champion International's Frenchtown Mill (Grimestad 1985).

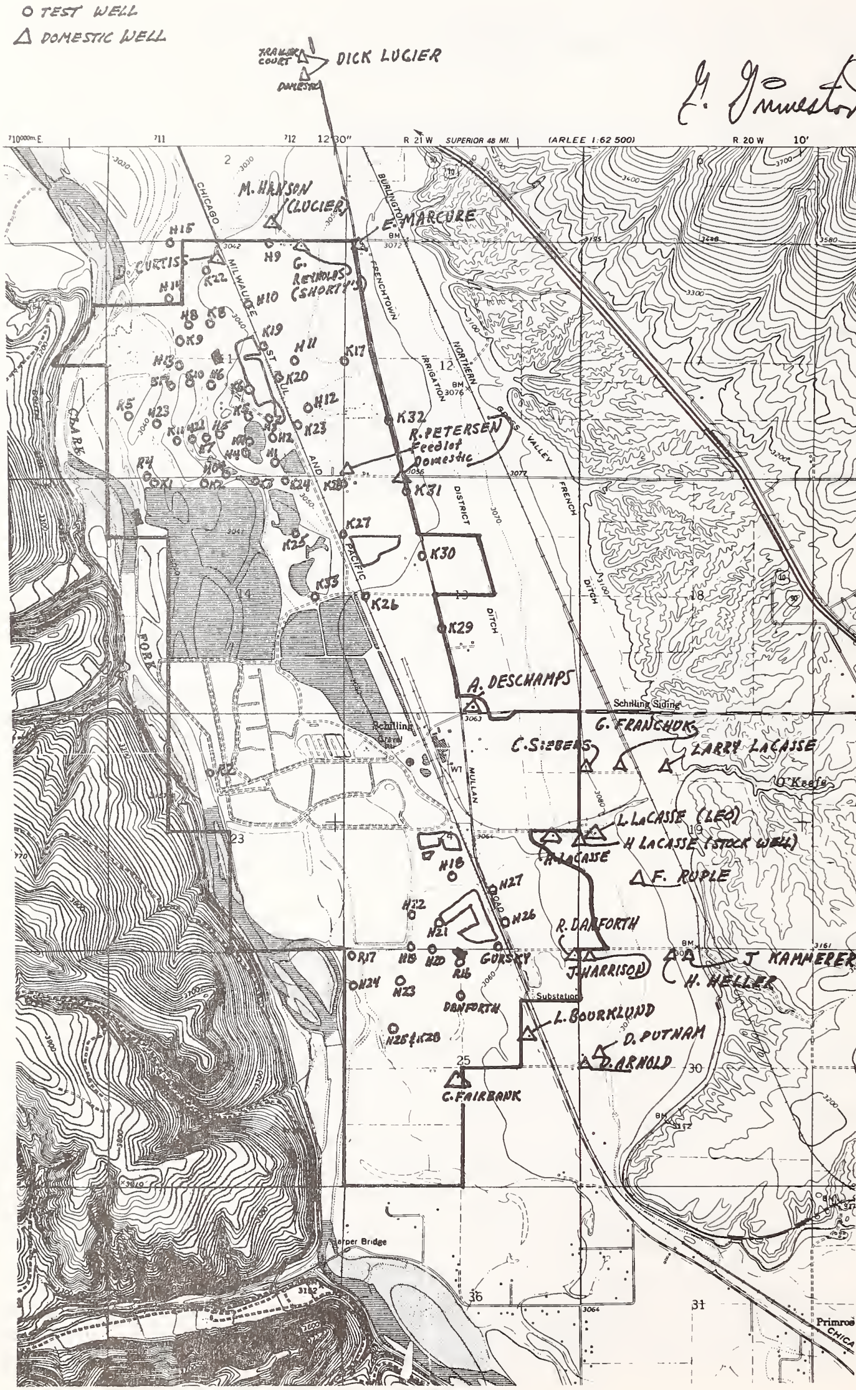


Table 16

BOUNDARY TEST WELL DATA

DATE	TEST WELL NUMBER	Na (ppm)	Cl (ppm)	CONDUCTIVITY (umhos/cm2)	COLOR (SCU)	LEVEL (ft)
3/26/85	H9	341	50	1066	13	---
4/25/85	H9	326	50	1254	15	3030
5/22/85	H9	340	104	1049	7	3030.4
6/25/85	H9	284	35	885	8	3030.4
7/22/85	H9	---	27	763	17	3030.5
8/22/85	H9	162	18	634	4	3033.1
9/13/85	H9	138	15	621	2	3033.1
10/14/85	H9	202	23	744	8	3031.4
3/26/85	K29	41	5	477	2	---
4/25/85	K29	---	--	---	--	---
5/22/85	K29	71	52	531	5	3040.2
6/25/85	K29	99	13	533	3	3043.5
7/22/85	K29	---	--	---	--	---
8/22/85	K29	80	14	455	1	3045.6
9/13/85	K29	36	3	402	2	3045.9
10/14/85	K29	42	4	462	2	3045.5
3/26/85	K30	135	7	417	44	---
4/25/85	K30	8	27	720	26	3041.3
5/22/85	K30	355	33	842	28	3040.9
6/25/85	K30	142	13	585	16	3044.2
7/22/85	K30	---	11	627	8	3044.5
8/22/85	K30	148	10	504	5	3045.7
9/13/85	K30	157	10	598	6	3046.8
10/14/85	K30	163	9	612	7	3045.7
3/26/85	K31	---	--	---	--	---
4/25/85	K31	23	35	1028	33	3040.5
5/22/85	K31	568	30	1010	83	3040.7
6/25/85	K31	454	24	877	102	3041.5
7/22/85	K31	---	18	653	51	3042.8
8/22/85	K31	326	14	683	26	3045.4
9/13/85	K31	298	11	644	46	3048.0
10/14/85	K31	213	10	658	10	3045.7
3/26/85	K32	67	10	472	3	---
4/25/85	K32	23	35	490	5	3040
5/22/85	K32	142	9	535	4	3039.6
6/25/85	K32	85	9	581	1	3040.4
7/22/85	K32	---	8	412	3	3042.3
8/22/85	K32	58	6	337	0	3044.3
9/13/85	K32	45	4	426	2	3046.2
10/14/85	K32	39	5	432	2	3044.5
11/19/85	P#1*	15.8	4.7	446	1.8	---
11/19/85	P#2	179	143	1470	21.5	---
11/19/85	P#7	9.1	4.8	298	1.8	---
11/19/85	P#11	8.8	4.7	438	1.4	---
11/19/85	P#13	12.8	4.0	358	1.4	---

*Private Wells

suspended particulate levels. There are no state or federal ambient standards for sulfates.

Table 17 describes the sulfate concentrations at the two monitoring sites near the Champion mill. Moderate levels of sulfates have been measured at both sites over the past four years. The sulfate concentrations have fluctuated during the period, but with no identifiable trends. The sulfate levels are very similar to those recorded at Rose Park 15 miles away in the city of Missoula. The DHES expects sulfate concentrations to remain relatively constant if Champion is granted a renewal of its discharge permit.

TABLE 17
SULFATE CONCENTRATIONS NEAR THE CHAMPION FRENCHTOWN MILL
(ug/m^3)

	Well Field Site #2			Railroad Bluff Site		
	Arith. Mean	Max. 24-hour	2nd High 24-hour	Arith. Mean	Max. 24-hour	2nd High 24-hour
1981	2.7	5.8	4.9	3.5	8.6	5.9
1982	1.9	8.7	7.9	2.3	16.5	9.2
1983	2.8	7.0	6.0	3.2	6.0	5.8
1984	2.9	12.2	12.1	3.2	11.0	9.9

Sulfur Dioxide

In addition to the sulfate monitors, Champion operates a hydrogen sulfide/sulfur dioxide analyzer at the Well Field site and Railroad Bluff site. The highest sulfur dioxide concentration recorded at either site was a 1-hour concentration of 0.025 parts per million (ppm) during 1980. This concentration is approximately 5 percent of the Montana 1-hour ambient standard. Since 1981, no sulfur dioxide has been measured on either analyzer.

Although ambient concentrations of sulfur dioxide appear to be extremely low in the vicinity of the Champion mill, that data should be interpreted with caution. The analyzers used by Champion to measure sulfur dioxide are not recognized by the EPA or the DHES as reference equivalent methods. In addition, the calibration procedures employed by Champion over the past two years were inadequate in regard to state and federal requirements.

The department expects sulfur dioxide levels to remain below minimum detectable levels if Champion's permit to discharge to the Clark Fork River is renewed.

Hydrogen Sulfide

Hydrogen sulfide levels at both the Well Field and the Railroad Bluff sites have exceeded the Montana hydrogen sulfide standard in each of the last five years (Table 18). The hydrogen sulfide concentrations have fluctuated from year to year, with 1981 and 1984 being particularly bad. The hydrogen sulfide data, especially for 1983 and 1984 should be

interpreted with caution since calibration procedures were inadequate during this period.

The highest concentrations usually occur during the summer and early spring. The spring peak appears to coincide with ice melt-off on the pond system while the summer increase seems to be caused by warmer weather and the increased storage of untreated wastes in the emergency spill ponds.

TABLE 18
HYDROGEN SULFIDE CONCENTRATIONS NEAR THE CHAMPION FRENCHTOWN MILL
(parts per billion (ppb))

	Well Field Site			Railroad Bluff Site		
	Arith. Mean	Max. 1-hour	Exceedences of MT Std	Arith. Mean	Max. 1-hour	of MT Std
1980	0.77	53	2	0.16	51	1
1981	2.97	191	87	0.97	146	16
1982	0.82	84	16	0.31	62	3
1983	1.61	154	32	0.13	58	4
1984	1.96	307	84	1.40	145	19

The warmer summer temperatures tend to increase the bacterial action in the ponds depleting the available oxygen supply, thereby creating anaerobic conditions and a corresponding increase in the production of hydrogen sulfide.

At the DHES' request, Champion conducted a short-term air monitoring survey during August, 1985. The survey monitored hydrogen sulfide at approximately 50 locations in and around the mill and effluent pond system and determined that the highest hydrogen sulfide concentration existed around emergency spill ponds #6 and #8 and pond #15W.

The high concentrations in the spill ponds are caused because the waste in these ponds is untreated effluent and therefore likely to be in an anaerobic state. In addition, the effluent in pond #15W is only partially treated waste, thus is also likely to be anaerobic. The waste in pond #15W was only partially treated because of the disturbance to the bacteria in the aeration basin during the resumption of operations from the summer shutdown period. When the waste was transferred to pond #15W it apparently became anaerobic. These conditions are likely to reoccur, in varying degrees, every year.

The information gathered during the 1985 short-term survey also seems to indicate that the mill itself is not a major source of hydrogen sulfide.

If Champion's permit to discharge to the Clark Fork river is renewed without modification to the waste treatment system, violations of the Montana hydrogen sulfide ambient air quality standard will continue to occur. Any violations of air quality will be subject to the provisions of the Montana Clean Air Act. The DHES' Air Quality Bureau is working with Champion to find ways to reduce the hydrogen sulfide levels. Several proposals are being considered including: (1) eliminating emergency spill

pond #6, (2) installing a pumping system in emergency spill pond #8 to pump wastewater to the aeration basin and thereby maintaining pond #8 in a nearly empty condition, (3) increasing the number of aerators in the aeration basin, (4) reconstructing the aeration basins to eliminate dead areas and (5) installing a new clarifier or increasing the capacity of the existing clarifier to remove the solids from all the effluent including that being discharged to the emergency spill ponds. It should be noted that most of these proposals are likely to also improve the quality of the waste being discharged to the Clark Fork River.

Total Suspended Particulates

Total suspended particulates are measured at two locations near the Champion mill. During the past five years, particulate concentrations slowly decreased until both sites recorded a 1984 geometric mean of 27 micrograms per cubic meter (ug/m^3). Table 19 describes in detail the particulate levels in the vicinity of the Champion mill. These levels are very low, especially when compared to the 1984 geometric mean of 57 ug/m^3 at the Boyd Park site in Missoula. The department expects the renewal of Champion's permit to discharge to the Clark Fork River would have an insignificant impact on total suspended particulates.

TABLE 19
TOTAL SUSPENDED PARTICULATE CONCENTRATIONS
NEAR THE CHAMPION FRENCHTOWN MILL

	Well Field Site				Railroad Bluff Site			
	Arith Mean	Geom Mean	Max 24-hour	2nd High 24-hour	Arith Mean	Geom Mean	Max 24-hour	2nd High 24-hour
1980	43	33	211	209	43	33	213	171
1981	32	25	122	100	38	25	106	96
1982	32	26	102	86	32	26	102	86
1983	30	24	143	101	30	26	80	69
1984	27	20	102	99	27	22	94	92

In-Plant Emissions

Champion conducts an extensive emission monitoring program within the plant and submits a monthly report to the DHES. Air Quality Permit No. 2R792-013025 issued on August 17, 1979 and modified September 1, 1982, sets forth the emission monitoring and reporting requirements. In addition, those sources which are part of Champion's recent plant expansion are subject to the New Source Performance Standards (NSPS) which include additional emission monitoring requirements.

Generally, the in-plant emissions are in compliance with all applicable standards. Occasional malfunctions cause the standard to be exceeded. All violations are promptly reported and explained in the monthly emission report.

UNIQUE, ENDANGERED, FRAGILE OR LIMITED ENVIRONMENTAL RESOURCES

Protecting air and water quality can be complex and difficult tasks. They are not only fragile resources, but in western Montana, are also unique when compared to similar resources throughout the United States.

Although there are impacts to air and water quality in the Missoula area from a number of sources, efforts are being made by local, state and federal officials, and many interested organizations and persons, to insure that legal standards are being met or will be met in the future.

DEMANDS ON ENVIRONMENTAL RESOURCES OF LAND, WATER, AIR AND ENERGY

There are demands placed on water and air resources, however there are limits to the demands in the form of air and water pollution standards. The discussions in the Water Quality and Air Quality Sections outline the major demands and discuss what is being done to insure the standards are adhered to by communities and businesses.

HISTORICAL AND ARCHAEOLOGICAL SITES

Champion's proposal to renew its discharge permit was described in a letter to the State Historic Preservation Office, along with a request to evaluate the proposal in light of possible historical or archaeological implications. David Schwab, an archaeologist and anthropologist with the office, reviewed the request and said:

> ...Given the scope of the proposed undertaking as we understand it, it does not appear that wastewater discharge will have any effect on significant cultural resources.
>
> This office should be consulted in advance if wastewater pond construction or any ground disturbing activities are planned as a result of increased wastewater discharge under this permit. At that time we will conduct a review and offer recommendations to avoid potential impacts to significant cultural resources.

HUMAN ENVIRONMENT

SOCIAL AND CULTURAL UNIQUENESS AND DIVERSITY

The belief that the water quality of the Clark Fork River might be effected by Champion's proposal to discharge into the river on a year around basis stirred a diverse number of persons and organizations.

From the Missoula area, down river to Lake Pend Oreille, the wood products and tourist industries are not only economically important, they greatly influence the social and cultural fabric of the people.

The ideas of using the renewable resources of the forest and yet preserving the natural quality of the countryside and streams, are important considerations for not only the people who live and work in western Montana and northern Idaho, but also for persons who live elsewhere and travel back to the area for varying periods of time.

People in the wood products industry find enjoyment in the amenities offered by outdoor recreation--hunting, fishing, picnicing, hiking and camping--as much as people in the tourist industry, and tourists themselves, use and depend on by-products from the wood manufacturing industry.

In terms of the proposed state action--granting, denying or conditionally granting a permit--the social and cultural effects at first glance seem minor. Missoula is one of Montana's largest cities and its diversity of people and groups is broad and varied. The mill's economic impact appears greater than the social and cultural contributions to the area. However when questions arose concerning the possible impacts of the proposed change in the discharge permit, the concern created a ripple effect that went from Missoula, through towns along the river, down to communities on and near Lake Pend Oreille in northern Idaho. People suddenly became concerned that possible negative impacts to the Clark Fork would directly effect the social and economic influences in their lives. These concerns manifested themselves in letters to the DHES, attendance at public meetings, the formation of groups specifically concerned with the future of the river, and the creation of a technical advisory committee.

The DHES received more than 250 letters from interested persons. At a public meeting in Missoula, testimony and more letters were presented to the department. There were also petitions: 675 signatures from persons in communities throughout northern Idaho, 514 signatures from the towns of St. Regis, Superior and Alberton and 133 signatures from the Missoula area.

The concerns varied greatly. They included statements such as:

--Champion is a major economic asset to Missoula, western Montana and northern Idaho--in favor of the proposal.

--People didn't want the present water quality of the river to worsen.

--Don't allow year round discharges and sampling while determining the effects on water quality.

--People were generally concerned--in light of historical impacts to the river--with additional damage to the Clark Fork.

--Letters requested a public hearing to discuss the proposal.

--Citizens wanted additional scientific studies to be done and an environmental impact statement written.

--Some were concerned with Champion's "self monitoring" program.

--There were requests that there be an "independent" analysis of the information collected for the impact statement--some person or persons other than the DHES or Champion.

--Concerns were raised as to the possible clogging effect of the effluent in the riverbed.

--The area needs the economic benefits of the mill, but the corporation should be conscientious enough to solve its own disposal problems.

--People recognize the difficult economic times and the contributions Champion makes to the economy in western Montana, but are more interested in seeing the water quality of the Clark Fork preserved.

--Some wanted Champion to explore other alternatives.

--Others were simply against the proposal.

The vast majority of the people and organizations that wrote or spoke about the proposal were not for it. Although opinions varied widely, the majority wanted better scientific information, which required a period of time for sampling, and the preparation of an environmental impact statement.

Most of the support for the mill came from the Missoula area, but conversely the greatest number of unfavorable letters also came from Missoula. The communities downstream from the mill were mostly either against the proposal or wanted better information and an impact statement. The downstream responses were not simply from outdoors' enthusiasts and recreational property owners, but included letters from chambers of commerce, city and county governments, legislators, professional people and local business persons.

The course of action ultimately chosen by the DHES was similar to that expressed by the majority of persons, this included doing two years of scientific studies and writing an environmental impact statement.

ECONOMICS

--Local and State Taxes
--Industrial Production and Energy Demands
--Quantity and Distribution of Community and Personal Income
--Quantity and Distribution of Employment
--Distribution and Density of Population
--Industrial, Commercial and Transportation Activity

The ensuing economic analysis is the result of a DHES request to Champion to address the economic considerations required for the draft EIS. Champion in turn hired the Bureau of Business and Economic Research, University of Montana, to gather the information and provide the appropriate analysis. The bureau's report follows.

The Missoula County Economy

Missoula County, with a 1984 population of approximately 76,500, is the third largest county in Montana. During the 1970s, it was among the most rapidly growing counties; the 1980 Census reported a gain of 30.5 percent, from 58,000-plus residents in 1970 to 76,000 in 1980. Between 1980 and 1984, population growth has been very slow; it actually declined in 1982, at the low point of the recent recession. The 1984 estimate is preliminary, but it indicates that Missoula County population has returned to its 1980 level (Table 20).

The lack of growth in population since 1980 is mostly a reflection of economic conditions. According to preliminary estimates, total personal income in the county in 1984 was less than 1 percent higher than in 1979 after adjustment for inflation (Table 21). During the recession, income fell each year between 1979 and 1982; the overall decline amounted to seven

Table 20

Missoula County Population,
1970 and 1980-1984

Year	Population
1970[a]	58,263
1980[a]	76,016
1981[b]	76,400
1982[b]	75,200
1983[b]	75,500
1984[c]	76,500

Source: U.S. Bureau of the Census.

[a]Census figure.
[b]Estimate.
[c]Provisional estimate.

Table 21

Personal Income,
Missoula County,
1979-1984

Year	--- Total Personal Income --- Thousands of Current Dollars	Thousands of Constant (1983) Dollars	---- Per Capita Income ---- Current Dollars	Constant (1983) Dollars
1979	$ 579,476	$ 761,699	$ 7,821	$ 10,277
1980	622,363	742,663	8,117	9,686
1981	646,676	710,180	8,463	9,290
1982	682,692	707,879	9,076	9,415
1983	739,659	739,659	9,764	9,764
1984[a]	798,150	773,401	10,351	10,030

Year	------- Labor Income[b] ------- Thousands of Current Dollars	Thousands of Constant (1983) Dollars	----- Nonlabor Income ----- Thousands of Current Dollars	Thousands of Constant (1983) Dollars
1979	$ 471,710	$ 620,045	$ 173,266	$ 227,682
1980	494,628	590,238	197,250	235,382
1981	484,720	532,320	230,132	252,615
1982	492,037	510,190	259,901	269,607
1983	543,432	543,432	273,716	273,716
1984[a]	580,900	562,888	296,475	287,282

Source: U.S. Bureau of Economic Analysis, Regional Economic Information System and University of Montana, Bureau of Business and Economic Research.

Note: Dollar figures deflated using the U.S. Department of Commerce implicit price deflator for personal consumption expenditures.

[a]Preliminary estimate.
[b]Before adjustment for social insurance payments and residence.

percent. Preliminary estimates for 1984 indicate that total personal income has climbed back to the 1979 level.

Per capita personal income--average income per person--declined by two percent between 1982 and 1979, again in constant dollars[12] (Table 21). Despite the large number of university students, whose income is typically low, per capita income in Missoula County in 1979 was almost four percent higher than in Montana. In 1984 it had dropped to two percent below the state figure.

Total personal income includes labor income (wages and salaries, certain fringe benefits and proprietors' income) plus property income and transfer payments. Property income includes rent, dividends and interest; transfer payments represent income from which no services are currently rendered, including Social Security and other retirement benefits, unemployment insurance, and various income maintenance payments.

Per capita income is total personal income divided by total population, or average income per person. It is commonly used to compare economic well being among residents of different areas.

No economic indicators comparable to gross national product (GNP-which measures the total United States output of goods and services) are available for Montana and its counties. Changes in labor income are often used as a proxy for GNP because in the short run they reflect changes in output.

Between 1979 and 1982, labor income declined almost 18 percent in Missoula County (Table 21 and Figure 28). Even after two years of increases in 1983 and 1984, the county economy still had not recovered to its prerecession level. Labor income was still 9 percent below the 1979 figure.

The wood products industry is the major determinant of short-term economic trends in Missoula County. The federal government, the University of Montana, the trucking industry and the pulp and paper industry, are important contributors to the economic base, but the county's economy turns on mortgage rates, the U.S. housing market and the lumber and wood products industry. The severity of the recent recession in Missoula County is evidence of the importance of the hard-hit wood products industry.

But, the slow recovery in business activity and labor income during this business cycle is also due to some permanent losses which have occurred in Missoula's economic base. Since 1979, the county has experienced a plywood plant closure, the loss of one railroad and sizable transfers of personnel out of Missoula by another, and a decline in federal employment. A detailed discussion of the county's economic base follows in a separate section.

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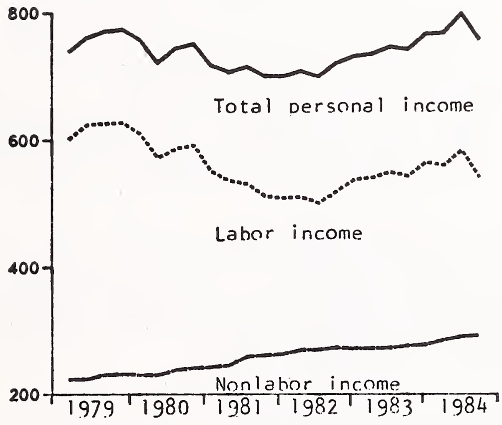
12 All the dollar figures in the tables are presented in two forms: as current and constant (1983) dollars. Current dollars are the dollar figures as reported each year. Constant dollars have been adjusted to remove the effects of inflation. In this report all constant dollars are expressed in terms of 1983 purchasing power.

Figure 28

Total Personal Income
Missoula County
1979-1984

(In Millions of Constant 1983 Dollars)



Sources: U.S. Bureau of Economic Analysis, Regional Economic Information System and University of Montana, Bureau of Business and Economic Research.

Notes: Labor income includes wages and salaries, certain fringe benefits, and proprietors' income. Nonlabor income includes rent, dividends, and interest payments to individuals, plus transfer payments. Dollar figures deflated using the U.S. Department of Commerce implicit price deflator for personal consumption expenditures.

The declines in labor income were counterbalanced by substantial increases in nonlabor income. If it were not for this growth in property income and transfer payments, total personal income would have fallen even further (Table 21 and Figure 28).

Just over 36,000 persons (wage and salary workers and self-employed) were at work in Missoula County in 1984, according to the Montana Department of Labor and Industry. This was about 2,000 workers, or six percent, higher than the 1979 figure. The unemployment rate in 1984 was estimated at 6.6 percent, about the same as in 1979 (Table 22). It had risen to over nine percent in 1981 and 1982.

Some fundamental changes have occurred in county employment patterns since 1979--changes which help explain an apparent increase in employment accompanied by a decline in labor income. Unfortunately, detailed employment figures for 1984 are not yet available, but the 1983 figures illustrate the underlying changes which have taken place. The number of wage and salary jobs in Missoula County declined by 2,700 between 1979 and 1983 (Table 23). The rise in total employment during this period is attributed to a large increase in self-employment. It could be that many individuals who could not find a wage and salary job entered some sort of self-employment. Even though some high-earning professionals are included among the self-employed, the average earnings in this category have historically been lower than for wage and salary workers.

Also, based on the 1983 figures in Table 24, it is clear that many of the jobs Missoula County has lost--in construction, wood products, railroads and the federal government--were among the highest-paying jobs in the county. The average annual earnings in those industries in 1983 were approximately $20,300, $23,100, $31,900 and $20,100 respectively, compared to $15,200 for all wage and salary workers.

During this period, the Frenchtown Mill was expanding its production capacity and increasing its employment. It added 130 new jobs between 1979 and 1983 and an additional 20 in 1984. As Table 24 indicates, average annual earnings in the paper industry are the highest in Missoula County.

Since 1979, then, Missoula County has lost a significant number of high-paying wage and salary jobs. And a good many county residents apparently have turned to some sort of self-employment to earn a living. As a result, both total labor income and per capita income were lower in 1984 than in 1979, after adjustment for inflation.

The Western Montana Economy

Although the Frenchtown Mill is located in Missoula County, its impact is felt throughout the forested areas west of the Continental Divide, mostly because of its purchases of residue (wood fiber) from outlying mills.

Montana's wood products industry is concentrated in seven western counties: Lincoln, Flathead, Sanders, Lake, Mineral, Missoula and Ravalli. About 85 or 90 percent of industry activity in the state occurs in those counties.

Table 22

Total Employment and Unemployment,
Missoula County,
1979-1984

		Unemployment	
Year	Total Employment[a]	Number	Percent of the Labor Force
1979	34,050	2,319	6.4
1980	33,103	2,713	7.6
1981	32,254	3,277	9.2
1982	32,068	3,248	9.2
1983	33,664	2,935	8.0
1984	36,050	2,558	6.6

Source: Montana Department of Labor and Industry (Current Population Survey Data).

Note: Not comparable to data in table 4.

[a]Includes the self-employed.

Table 23

Number of Wage and Salary Jobs by Major Industry,
Missoula County,
1979 and 1983

	1979	1983
Total wage and salary jobs	33,758	31,057
Construction	2,361	1,342
Manufacturing	4,860	4,091
Wood products	3,160	2,340
Paper	583	717
All other	1,117	1,034
Transportation and utilities	2,524	2,172
Railroads	699	413
All other	1,825	1,759
Wholesale trade	1,735	1,445
Retail trade	6,359	6,378
Finance, insurance, real estate	1,379	1,282
Services	6,408	6,606
Medical and health	2,164	2,419
All other	4,244	4,187
Government	7,906	7,441
Federal	2,002	1,801
State and local	5,904	5,640
All other[a]	226	300

Source: U.S. Bureau of Economic Analysis, Regional Economic Information System and Champion International Corporation.

Note: Not comparable to data in table 3.

[a]Includes agriculture, agricultural services, forestry, fisheries, and mining.

Table 24

Average Annual Earnings by Industry, Wage and Salary Workers, Missoula County, 1983

	Average Annual Earnings[a]
All wage and salary workers	$ 15,241
Construction	20,315
Manufacturing	23,289
Wood products	23,134
Paper	34,747
All other	15,719
Transportation and utilities	21,689
Railroads	31,947
All other	19,869
Wholesale trade	16,593
Retail trade	9,264
Finance, insurance, real estate	14,694
Services	12,059
Medical and health	16,905
All other	9,260
Government	15,684
Federal	20,112
State and local	14,271
All other industries[b]	18,053

Source: U.S. Bureau of Economic Analysis, Regional Economic Information System.

[a] Wages and salaries.
[b] Includes agriculture, agricultural services, forestry, fisheries, and mining.

The economic trends in the seven-county area have been similar to those in Missoula County. Between 1970 and 1980, the combined population of the seven counties grew 29 percent. Growth slowed during the recession, but in 1984 the population estimate of the area, at 207,200 was four percent above 1980 (Table 25).

Total personal income in western Montana declined five percent between 1979 and 1982, in constant dollars. Preliminary estimates for 1984 put it at three percent above the 1979 figure.

Per capita income in the seven counties combined is traditionally lower than in Missoula County. In 1979, it was seven percent lower than in Missoula County and four percent below the state figure. In 1984, it still was seven percent below Missoula County, and had fallen to nine percent lower than the state (Table 26).

As in Missoula County, the wood products industry is the major contributor to the western Montana economic base; the area's economy is equally volatile. During the recent recession, total labor income fell 19 percent between 1979 and 1982. It remained about 10 percent below the 1979 figure in 1984, indicating that total business activity in western Montana has not returned to pre-recession levels. As was the case in Missoula County, increases in property income and transfer payments offset these losses and pushed 1984 total personal income slightly above the 1979 level (Table 26 and Figure 29).

Total employment in western Montana declined in 1980 and did not return to the 1979 figure until 1983. In 1984, after two years of strong recovery, total employment in the seven western counties was estimated to be 12 percent above 1979. Unemployment, which had climbed to 12.2 percent during the recession, had declined to 8.4 percent. In 1979, it was 6.9 percent of the labor force (Table 27).

Since 1979, western Montana also has recorded increases in total employment while labor income--income from participation in the labor force--has declined. The reason, as in the case of Missoula County, was substantial increases in self-employment. The number of wage and salary jobs in 1983 (latest figures available) was almost 4,000 lower than in 1979 (Table 28). The seven-county area also has lost high-paying wage and salary jobs in wood products, railroads, construction, and the federal government.

In addition to the 130 new jobs at the Frenchtown Mill between 1979 and 1983, its expansion resulted in about 100 new jobs with western Montana trucking firms hauling residue to the plant. The impact of the mill on the transportation industry is discussed more fully later.

Some 400 new mining jobs also were created in western Montana during this period. Nevertheless, as in Missoula County, labor income and per capita income were lower in 1984 than in 1979, when measured in constant dollars.

The Frenchtown Mill

Champion International's Montana operations include approximately 900,000 acres of timberland, four sawmills, two plywood plants, and a pulp

Table 25

Western Montana Population, 1970 and 1980-1984

Year	Population
1970[a]	154,691
1980[a]	199,633
1981[b]	201,200
1982[b]	201,000
1983[b]	203,700
1984[c]	207,200

Source: U.S. Bureau of the Census.

Note: Includes Lincoln, Flathead, Sanders, Lake, Mineral, Missoula, and Ravalli counties.

[a] Census figure.
[b] Estimate.
[c] Provisional estimate.

Table 26

Personal Income,
Western Montana,
1979-1984

Year	Total Personal Income: Thousands of Current Dollars	Total Personal Income: Thousands of Constant (1983) Dollars	Per Capita Income: Current Dollars	Per Capita Income: Constant (1983) Dollars
1979	$ 1,429,574	$ 1,879,120	$ 7,275	$ 9,563
1980	1,529,322	1,824,934	7,661	9,141
1981	1,638,670	1,799,588	8,144	8,944
1982	1,716,834	1,780,174	8,541	8,857
1983	1,858,774	1,858,774	9,125	9,125
1984[a]	2,004,575	1,942,418	9,620	9,322

Year	Labor Income[b]: Thousands of Current Dollars	Labor Income[b]: Thousands of Constant (1983) Dollars	Nonlabor Income: Thousands of Current Dollars	Nonlabor Income: Thousands of Constant (1983) Dollars
1979	$ 1,024,698	$ 1,346,926	$ 404,876	$ 532,194
1980	1,048,568	1,251,252	480,754	573,682
1981	1,060,108	1,164,211	578,562	635,377
1982	1,050,219	1,088,965	666,615	691,209
1983	1,172,213	1,172,213	686,561	686,561
1984[a]	1,252,100	1,213,275	712,820	690,717

Source: U.S. Bureau of Economic Analysis, Regional Economic Information System, and University of Montana, Bureau of Business and Economic Research.

Notes: Dollar figures deflated using the U.S. Department of Commerce implicit price deflator for personal consumption expenditures.

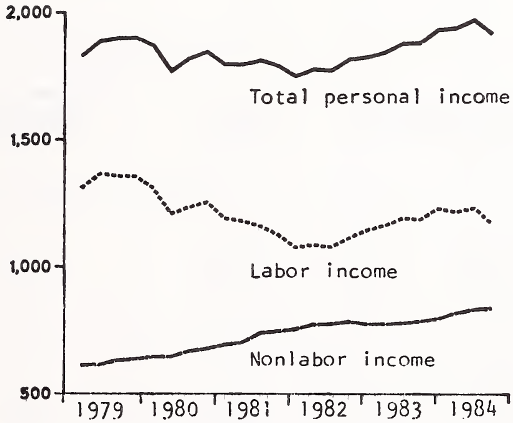
Includes Lincoln, Flathead, Sanders, Lake, Mineral, Missoula, and Ravalli counties.

[a] Preliminary estimate.
[b] Before adjustment for social insurance payments and residence.

Figure 29

Total Personal Income
Western Montana
1979-1984

(In Millions of Constant 1983 Dollars)



Sources: U.S. Bureau of Economic Analysis, Regional Economic Information System and University of Montana, Bureau of Business and Economic Research.

Notes: Labor income includes wages and salaries, certain fringe benefits, and proprietors' income. Nonlabor income includes rent, dividends, and interest payments to individuals, plus transfer payments. Western Montana includes Lincoln, Flathead, Sanders, Lake, Mineral, Missoula, and Ravalli counties. Dollar figures deflated using the U.S. Department of Commerce implicit price deflator for personal consumption expenditures.

Table 27

Total Employment and Unemployment,
Western Montana,
1979-1984

		-------- Unemployment -------	
Year	Total Employment[a]	Number	Percent of the Labor Force
1979	82,571	6,134	6.9
1980	80,181	7,715	8.8
1981	80,688	9,139	10.2
1982	80,157	11,140	12.2
1983	86,179	9,637	10.1
1984	92,175	8,459	8.4

Source: Montana Department of Labor and Industry (Current Population Survey data.)

Notes: Includes Lincoln, Flathead, Sanders, Lake, Mineral, Missoula, and Ravalli counties. Not comparable to data in table 9.

[a]Includes the self-employed.

Table 28

Number of Wage and Salary Jobs
by Major Industry,
Western Montana,
1979 and 1983

	1979	1983
Total wage and salary jobs	72,335	68,381
Mining	324	733
Construction	4,283	2,831
Manufacturing	12,479	10,509
Wood products	8,525	7,147
Paper	583	717
All other	3,371	2,645
Transportation and utilities	5,120	4,253
Railroads	1,607	948
All other	3,513	3,305
Wholesale trade	2,811	2,590
Retail trade	13,447	13,503
Finance, insurance, real estate	2,681	2,675
Services	13,221	13,944
Medical and health	4,262	5,143
All other	8,959	8,801
Government	16,874	16,225
Federal	5,401	4,986
State and local	11,473	11,239
All other[a]	1,095	1,118

Source: U.S. Bureau of Economic Analysis, Regional Economic Information System and Champion International Corporation.

Notes: Includes Lincoln, Flathead, Sanders, Lake, Mineral, Missoula, and Ravalli counties. Not comparable to data in table 8.

[a]Includes agriculture, agricultural services, forestry, and fisheries.

and paper mill. The headquarters of Champion's western United States timberlands operations is also located in Montana, in Missoula County.

Management of the timberlands and the operation of the mills employ 2,840 people in Montana, nearly one-third of the state's total forest products employment. If independent loggers supplying timber to the Champion mills are counted, approximately 40 percent of Montana's forest products work force is based on Champion's operations.

The term forest products as used in this report refers to two industries in the Standard Industrial Classification Code: lumber and wood products (except mobile homes) and paper and allied products. Because they are so closely related, the two are frequently referred to as the forest products industry.

The Champion International Corporation pulp and paper mill in Frenchtown is certainly the single most important facility among Montana's forest products plants. In operation since 1957, and purchased by Champion in 1977, its capacity was expanded to 1,850 tons of Kraft pulp, paper and linerboard per day in 1981.

The plant currently employs more than 700 workers, most of whom (88 percent) live in Missoula County. Other employees reside in Mineral, Ravalli, and Lake counties, all within the Missoula shopping area (Table 29).

In 1984, the mill's payroll was nearly $28 million (current dollars). That same year the plant had additional expenditures of $80 million in Montana, of which $21 million was spent in Missoula County. The corporation also paid $5.4 million in property taxes. Some $5 million of these taxes went to Missoula County.

It also provides an outlet for approximately 1.0 to 1.2 million bone dry units (BDUs) of wood residue annually.[13] Nearly all this residue is purchased in Montana. These purchases, and other countercyclical aspects of the mill operation, have helped to cushion the impact of downturns in the lumber and plywood markets. They also have helped solve an expensive wood waste disposal problem which can contribute to poor air quality in timbered areas.

Mill employees are well paid. The average wage or salary in 1984 was $37,430; the median (midway value) was approximately the same (Table 30). No other industry in the area provides jobs which pay so well. They have assumed even greater importance as employment in other high-paying industries has declined.

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13 A bone dry unit is 2,400 pounds, oven dry weight.

Table 29

Residence of Frenchtown Mill Employees, August 1985

Area	Number of Employees
Missoula County, total	639
Missoula city area	502
Frenchtown area	78
Huson	31
Milltown-Bonner area	4
Clinton	4
Lolo area	20
Mineral County, total	21
Alberton	18
Superior	3
Ravalli County, total	35
Florence	17
Stevensville	12
Victor	4
Hamilton	2
Lake County, total	33
Arlee	30
Ravalli	1
St. Ignatius	2
Total	728

Source: Champion International Corporation.

Table 30

Distribution of Wages and Salaries,
Frenchtown Mill,
1984

Annual Wage or Salary	Number	Percent of Total
Less than $25,000	120	15.3
$25,000 - $34,999	196	25.1
$35,000 - $44,999	296	37.9
$45,000 - $54,999	145	18.5
Over $55,000	25	3.2
Total	782	100.0

Source: Champion International Corporation.

Median wage or salary: $37,500.
Average wage or salary: $37,430.

Its Role as Part of an Integrated Forest Products Industry[14]

The significance of the Frenchtown Mill is related to its role in the integrated forest products industry in the state and western Montana.

The large level of utilization of wood residue from sawmills and plywood plants makes the pulp and paper mill an integral part of the forest products industry in the state. The major benefit to the industry is coverting residue--which can be both a source of pollution and an expensive disposal problem--into an important revenue source for Montana sawmills and plywood plants.

More than 90 percent of the timber harvested in Montana is processed by mills producing lumber and plywood. But less than one-half of the wood fiber in the timber delivered to mills actually becomes lumber or plywood. Much of the remaining wood fiber (referred to as mill residue) is used as a raw material and fuel by the pulp and paper mill in Frenchtown. Since the expansion in 1981, the mill has utilized 955,000 to 1,200,000 BDUs of residue per year, purchased from Montana wood products firms (Table 31). In 1984, the amount purchased represented approximately 60 percent of the residue produced in the state.

Since 1981, payments for mill residue to Montana mills have ranged between $24 million and $32 million annually and have accounted for between six and 12 percent of total revenue received by sawmills and plywood plants in the state (Figure 30 and Table 32). Typically more than 80 percent of total expenditures for residue in the state are made in western Montana and 25 to 40 percent in Missoula County alone. These figures include purchases from Champion's own wood products plants.

Countercyclical Aspects. As Figure 30 illustrates, residue purchases have exerted a countercyclical influence on the lumber and plywood industry. Changes in the national demand for pulp and paper generally lag behind changes in demand for lumber. A decline in lumber production means a reduction in the volume of mill residue available. If there is no corresponding decline in the demand for residue, the price may rise. During the recent recession, the price of chips, the component of mill residue most in demand by the pulp and paper industry, rose dramatically as users from throughout the northwest expanded their normal supply zones and attempted to purchase increased volumes in competition with the Montana mill.

The sale of residue keep some mills operating during periods of weak demand and poor prices for lumber. In fact, during the recession year of 1981, some sawmills in the state received more than 25 percent of their total revenue from the sale of residues.

The existence of a pulp and paper industry also helps to temper the cyclical nature of the logging industry. When the output of lumber and plywood declines, so does the demand for timber to produce these products.

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14 In addition to the sources indicated on the Tables, a forest industries data base, maintained by the Bureau of Business and Economic Research, University of Montana, was used to prepare this section.

Table 31

Volume of Mill Residue and Roundwood Purchased by the Frenchtown Mill, 1979-1984

	Roundwood	Mill Residue			
Year	Missoula County[a]	Missoula County	Western Montana	Montana, Total	All Purchases[b]
	Thousands of CCFs	Thousands of BDUs			
1979	0	340	638	791	821
1980	85	234	506	580	593
1981	95	345	835	979	1,062
1982	133	331	818	955	986
1983	51	355	1,029	1,206	1,271
1984	37	323	899	1,153	1,253

Source: Champion International Corporation.

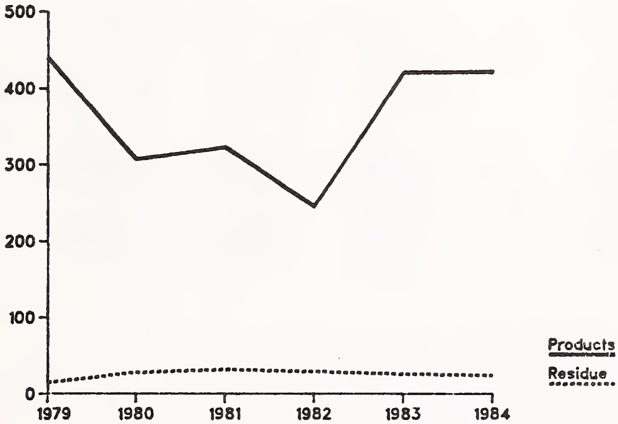
Note: Western Montana includes Lincoln, Flathead, Sanders, Lake, Mineral, Missoula, and Ravalli counties.

[a]Includes roundwood chipped at the plant and in the field. All roundwood purchases were made in Missoula County.
[b]Includes out of state purchases.

Figure 30

Total Revenue Received by Montana Producers
from Sales of Lumber and Plywood and
from Sales of Mill Residue to the Frenchtown Mill,
1979-1984

(Millions of Dollars)



Sources: Champion International Corporation; American Plywood Association; USDA Forest Service; Western Wood Products Association; and University of Montana, Bureau of Business and Economic Research.

Table 32

Expenditures for Mill Residue and Roundwood, Frenchtown Mill, 1979-1984

(Thousands of Dollars)

	- Roundwood -	---------- Mill Residue[b] ----------			
Year	Missoula County[a]	Missoula County	Western Montana	Montana, Total	All Expenditures[c]
1979	0	$ 6,658	$ 12,487	$ 15,478	$ 16,049
1980	$ 4,231	11,320	24,429	28,018	28,643
1981	5,061	11,263	27,294	32,002	34,698
1982	4,377	10,113	24,965	29,141	30,092
1983	686	7,266	21,032	25,976	27,650
1984	611	6,780	18,874	24,205	26,316

Source: Champion International Corporation.

Note: Western Montana includes Lincoln, Flathead, Sanders, Lake, Mineral, Missoula, and Ravalli counties.

[a]Includes roundwood chipped at the plant and in the field. All roundwood purchases were made in Missoula County. Figures represent total delivered cost.
[b]Does not include freight charges.
[c]Includes out of state purchases.

Because of increasing prices for chips during recession years, some loggers have harvested timber for use by the Frenchtown Mill.

In 1982 the pulp and paper mill paid over $4 million for 133 thousand cunits (CCFs a measurement unit in which one unit = 100 cubic feet of solid wood) of timber either in round form or chipped.[15] In 1984, a year of high lumber and plywood output, the Mill purchased only 37 thousand CCFs of roundwood, for $0.6 million (Table 32).

Reduced Air Pollution. Before the Frenchtown Mill was in operation, most of the unutilized mill residue in Montana was burned in teepee burners, contributing to poor air quality. As noted above, a large proportion (60 percent in 1984) of residue from Montana producers is now utilized by the mill as a valuable resource, thereby greatly reducing the disposal problem.

Its Role in the Missoula County and Western Montana Economies

The Frenchtown Mill is an important part of both the Missoula County and western Montana economies. This was especially evident during the recent recession.

As other industries, including wood products, were forced to reduce their employment, the paper mill increased the number of its employees from 583 in 1979 to 739 in 1984. The total payroll increased by 39 percent, from $19.2 million to $26.8 million in constant dollars (Table 33). The increases were due to an expansion of mill capacity which, luckily for western Montana, coincided with the recession.

Employment and wages and salaries did decline in 1982, as plant construction ended and the paper market began to weaken. There were some periods of layoffs and reduced production in both 1982 and 1983. But the mill proved much less cyclical than either the wood products industry or the Missoula and western Montana economies.

Contribution to the Economic base. When analyzing a region such as Missoula County or western Montana, economists divide the economy into basic and derivative components. Basic (or export) industries depend heavily on markets outside the area or are influenced by factors originating beyond the region's borders. The major examples of basic industries in Missoula County and western Montana are wood products, pulp and paper, transportation, the federal government and the university of Montana. The labor income of workers in the basic industries represents an injection of new funds into the local economy, which create additional incomes as the money is spent and respent locally. These basic industies are sometimes referred to as the economic base.

Derivative industries, on the other hand, serve the basic industries and the local population. Some derivative firms (which are called "closely linked") sell directly to the basic industries--for example, those

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15 A cunit is 100 cubic feet of solid wood. For the species utilized in Montana, this is approximately 2,500 pounds, oven dry weight.

Table 33

Employment and Payrolls,
Frenchtown Mill,
1979–1984

		Payroll[a]	
Year	Employment	Current Dollars	Constant 1983 Dollars
1979	583	$ 14,646,000	$ 19,246,000
1980	668	19,602,000	23,392,000
1981	709	21,785,000	23,914,000
1982	652	20,810,000	21,587,000
1983	717	24,983,000	24,983,000
1984	739	27,661,000	26,803,000

Source: Champion International Corporation.

Note: Dollar figures deflated using the U.S. Department of Commerce implicit price deflator for personal consumption expenditures.

[a]Includes wages and salaries. Not comparable to labor income figures used in figures 4 and 5.

companies selling natural gas and electricity, insurance, and repair services. Other derivative firms are not obviously connected to the economic base because they serve the entire population--examples include food stores, banks, doctors and local government.

The important point is that changes (either increases or decreases) in basic industries will lead to further changes in derivative industries. A rise in pulp and paper production will, for example, lead to an increase in the demand for natural gas and electricity, as well as higher sales at grocery stores and barber shops as the Champion workers spend their incomes.

Labor income (wages and salaries, certain fringe benefits, and proprietors' income) is the best measure of an industry's contribution to the local economic base. It is more accurate than employment, or any other indicator, because it takes into account differences in wage rates, work schedules and other factors which sometimes cloud interindustry comparisons.

Labor income in Missoula's basic industries during 1979 and 1984, is presented in Figure 31. The numbers have been converted to constant dollars to eliminate the effects of inflation. Labor income in Missoula County's basic industries totaled about $236.1 million (1983 dollars) during 1984, down about 10 percent from $261.8 million (1983 dollars) in 1979. This decline in Missoula's economic base was due to the long and severe recession of the early 1980s and to the permanent closures and job losses referred to previously.

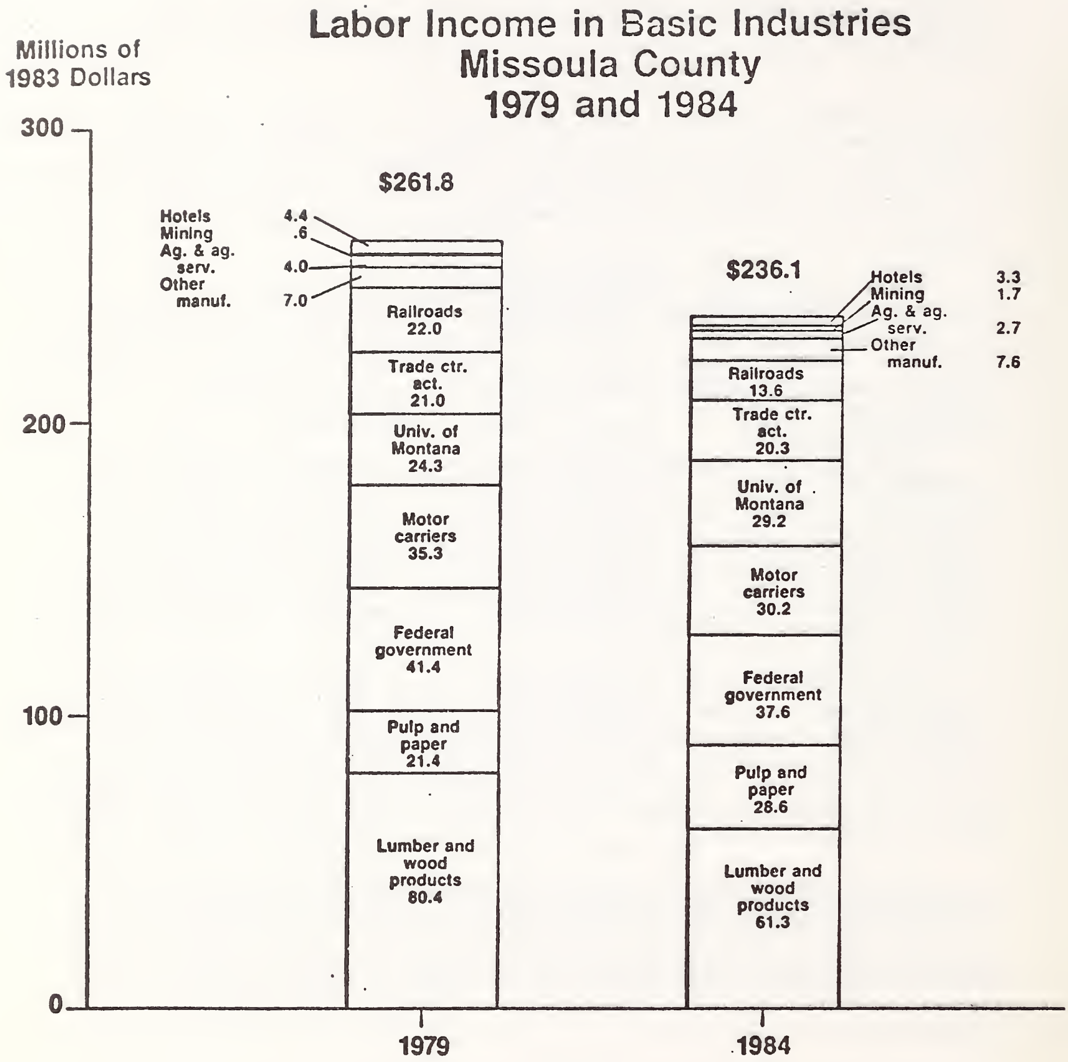
The expansion of the Frenchtown Mill and the decline in other basic industries has increased the mill's importance as part of Missoula County's economic base. Labor income of mill employees rose from $21.4 million (1983 dollars) in 1979 to about $28.6 million (1983 dollars) in 1984, a rise of 34 percent. Stated differently, the mill accounted for about eight percent of Missoula's economic base in 1979, while the corresponding figure was 12 percent in 1984.

The Frenchtown Mill was one of the few industries in Missoula County to experience an increase in labor income between 1979 and 1984. That increase helped moderate the recession in Missoula. Besides the mill, only the University of Montana and other manufacturing (which includes a number of small industries) grew between 1979 and 1984. If it were not for the Frenchtown Mill, the decline in Missoula's economic base would have been even greater.

The labor income figures understate the countercyclic impact in the Missoula economy during the recent recession because they do not include the earnings of the construction workers associated with the plant expansion during the 1979-1981 period.

Figure 32 presents labor income for basic industries in the seven western Montana counties. For this larger region, data for 1983 are the latest available. As in Missoula County, the economic base declined in western Montana as labor income dropped from $552.4 million (1983 dollars) in 1979 to $470.7 million (1983 dollars) in 1983, a decrease of 15 percent.

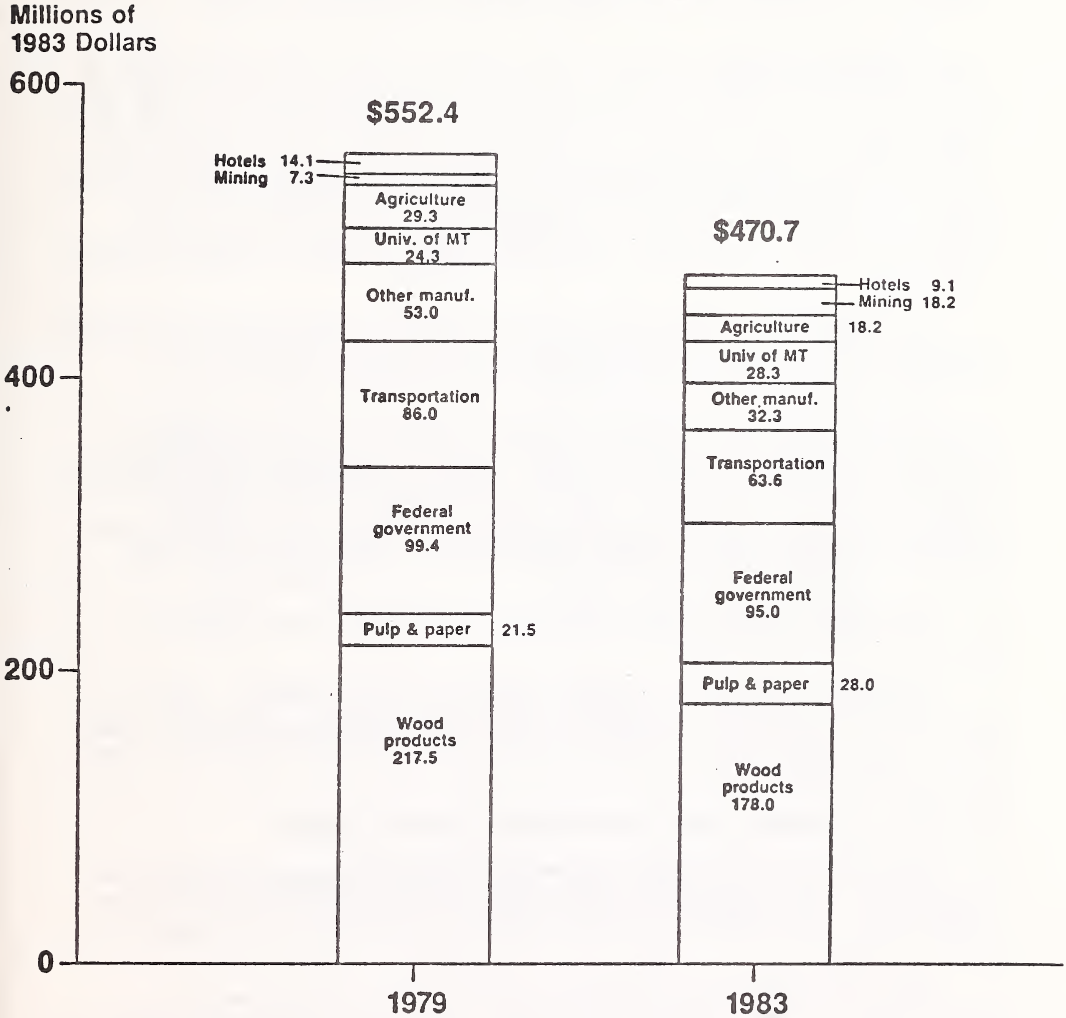
Figure 31



Sources: U.S. Bureau of Economic Analysis and University of Montana, Bureau of Business and Economic Research.

Figure 32

Labor Income in Basic Industries Seven Western Montana Counties 1979 and 1983



Sources: U.S. Bureau of Economic Analysis and University of Montana, Bureau of Business and Economic Research.

Note: Western counties include Lincoln, Flathead, Sanders, Lake, Mineral, Missoula, and Ravalli.

The Frenchtown Mill accounted for about four percent of western Montana's economic base in 1979. This figure rose to six percent in 1983. The increases at the mill were one of the few bright spots in the western portion of the state. Only mining experienced a greater increase in labor income, due primarily to the opening of the ASARCO mine at Troy.

Mill Expenditures. Economic base theory states that expenditures by basic industies create activity in derivative industries. While about 31 percent ($24.8 million) of the Frenchtown Mill's expenditures in 1984 went for purchases of raw materials from another important and closely-related basic industry--wood products, the balance ($55 million) was spent with other Montana businesses (Table 34). Probably the greatest impact outside the forest products industry has occurred in transportation. In 1984, almost $20 million was paid to Montana truckers and the railroad for hauling residue to the plant. Two-thirds went to firms in western Montana (Table 35).

The expansion of the Frenchtown Mill has been paralleled by the growth of the trucking firms serving it. Table 36 documents the growth of employment and payrolls among companies hauling to the mill.

Other major mill expenditures go for energy. In 1984, purchases of natural gas amounted to almost $14 million and purchases of electricity amounted to almost $8 million in 1984. The mill is Montana Power Company's largest industrial customer. Another $2.5 million went to freight companies located in Missoula County hauling products other than residue and $10.3 million went for other expenditures. Almost all of the $10 million was spent in Missoula County.

In total, the mill spent $21 million in Missoula County and $80 million in Montana in 1984.

Property taxes paid by the mill amounted to $5.4 million. Over $5 million went to Missoula County for county administration, schools, roads, bus service, rural fire fighting, and library services. The balance went to the state (Table 37).

The Mill in Missoula County's and Western Montana's Future

Until the Missoula County and western Montana economies become more diversified, their future will continue to be closely tied to the forest industries. This suggests that both areas, at best, are in a slow or no growth situation.

Over past decades, more and more of the state's "old growth or large-diameter timber has been harvested. There is a diminishing supply of large-diameter trees available to be harvested now, and much of the supply is less accessible than that portion already cut.

Because there are fewer large-diameter trees available, Montana's forest products industry must shift to an emphasis on small-diameter timber to remain viable.

In general, we can expect in the next two decades that the industry will move away from traditional large-log facilities such as plywood plants

Table 34

Expenditures in Missoula County and Montana,
Frenchtown Mill,
1984

(Thousands of Dollars)

	Missoula County	Montana, Total
Wood fiber	$ 7,391	$ 24,816
Wood transport	1,470	19,864
Energy		
Natural gas	---	13,815
Electricity	---	7,853
Coke	---	269
Oil	---	214
Local freight	2,550	2,550
Other expenditures	9,306	10,329
Total	20,717	79,710

Source: Champion International Corporation.

Note: Does not include payroll and property taxes.

Table 35

Expenditures for Transportation of Mill Residue, Frenchtown Mill, 1979-1984

(Thousands of Dollars)

Year	Missoula County	Western Montana	Montana, Total	All Expenditures[a]
1979	$ 1,243	$ 4,972	$ 7,266	$ 7,975
1980	1,137	5,940	7,782	8,135
1981	1,301	9,175	12,361	14,266
1982	1,483	8,996	12,740	13,903
1983	1,461	12,601	18,642	21,079
1984	1,470	12,730	19,864	23,738

Source: Champion International Corporation.

Note: Western Montana includes Lincoln, Flathead, Sanders, Lake, Mineral, Missoula, and Ravalli counties.

[a]Includes freight on residue purchased out of state.

Table 36

Employment and Payrolls
Attributable to Residue Hauling,
Montana Trucking Firms,
1979-1984

		Payroll[a]	
Year	Employment	Current Dollars	Constant 1983 Dollars
1979	131	$ 2,679,000	$ 3,520,000
1980	138	2,905,000	3,467,000
1981	177	3,488,000	3,829,000
1982	189	4,037,000	4,188,000
1983	228	4,954,000	4,954,000
1984	251	6,112,000	5,923,000

Source: Champion International Corporation.

Note: Dollar figures deflated using the U.S. Department of Commerce implicit price deflator for personal consumption expenditures.

[a]Includes wages and salaries.

Table 37

Property Taxes Paid,
Frenchtown Mill,
1984

Purpose	Tax
State	$ 351,000
County	1,147,000
County schools	1,636,000
District schools	1,625,000
Roads	265,000
Mountain Bus Line	161,000
Health	97,000
Rural fire	95,000
Library	71,000
Total	$ 5,448,000

Source: Champion International Corporation.

and sawmills processing large-diameter timber. If the large-log mills are replaced it will likely be by small-log facilities such as stud mills or waferboard plants.

This shift could have a major impact on western Montana's economy. From 1,000 to 3,000 wood products jobs could be lost, most of them in western Montana. Based on 1983 average wage rates, the payroll loss would range from $23 to $69 million in 1983 dollars.[16]

The impact on average earnings in lumber and wood products could also be substantial. At present, workers in the plywood sector are among the highest paid in Montana's wood products industry. Production workers at stud mills, though still receiving relatively high wage rates, are generally paid less than plywood workers. So the wood products industry would not only have fewer jobs in total, but the average earnings per job might also be lower. Presumably the earnings of pulp and paper industry workers would not be affected by these structural changes.

As of 1985, only one component of western Montana's economic base--mining--appears likely to experience significant expansion in the foreseeable future. Some of the best prospects appear to be in Lincoln County. A few hundred jobs at most are involved. On the other hand, the future of another major basic industry--the aluminum plant at Columbia Falls--is in jeopardy. The plan employs around 1,000 workers.

With the recent expansion at Frenchtown completed, further sizable increases in its production are unlikely. It is obvious, however, that the mill will continue to be an important factor in the health of the forest industries and in the Missoula County and western Montana economies.

As the structure of the wood products industry changes, and if industry employment does decline, continued operation of the paper mill and the jobs and income it provides will assume even greater importance to Missoula and western Montana. At the same time, the wood products industry will continue to rely on residue sales for revenue and for the stabilizing influence those sales represent.

HUMAN HEALTH

Refer to the Water Quality Section.

ACCESS TO AND QUALITY OF RECREATIONAL AND WILDERNESS ACTIVITIES

The Clark Fork River is an important recreational resource in western Montana and northern Idaho. Not only does it provide the popular amenities of fishing, swimming and floating, but also attracts duck hunters, bird watchers, hikers, campers and those who find relaxation in simply sitting and watching the river.

The river does have some unattractive features, such as foam and periodic growths of undesirable aquatic vegetation, however neither have

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16 Based on Charles E. Keegan III and Timothy P. Jackson "The Future of Montana's Forest Products Industry," Montana Business Quarterly, Autumn 1984.

been found to be directly attributable to discharges from the Champion mill.

There is a great deal of regional concern with maintaining the quality of the Clark Fork. This concern was emphasized in the many letters and public statements made to the DHES during periods of public comment two years ago. Since then, many things have happened to insure the recreational opportunities of the Clark Fork remain important considerations. Concerned citizens have organized groups to support research and planning; local, state and federal agencies are laying the groundwork for future studies and monitoring; established public interest organizations are helping people find means for making sure their concerns are addressed, and the two years of research and subsequent environmental impact statement have added appreciably to the body of knowledge needed to ultimately understand and guarantee the quality of river system.

DEMANDS FOR GOVERNMENT SERVICES

If the mill continues to discharge, monitoring will continue. If the proposed method of discharging on a year round basis is permitted, both Champion and DHES will need to continue monitoring efforts.

The mill's monitoring will be a cost of doing business, however the state's costs will have to be paid for from yet unknown sources of funding.

LOCALLY ADOPTED ENVIRONMENTAL PLANS AND GOALS

Missoula's city and county governments, under the auspices of the Missoula City-County Planning Board have developed long-term goals and objectives to guide growth and development. In the community's Policy Guide for Future Growth, under the goals and objectives for health, the statement is made that "A quality environment is a prerequisite for the good health and well being of individuals and the community... and one of the ways to accomplish that is to continually...improve water pollution controls and enforcement."

Another area that alludes to preserving water quality is in the goals and objectives for aesthetics. The plan notes that Missoula's natural surroundings must be preserved and protected, which includes protecting the "natural states" of the streams and Clark Fork riverfront.

PRIMARY, SECONDARY AND CUMULATIVE IMPACTS

The major concern is whether Champion International's discharge of treated wastewater on a year around basis will seriously affect water quality.

A number of scientific and technical studies indicate the mill can discharge into the river throughout the year if it is done in compliance with of the state's wastewater discharge permit.

Even when the mill is meeting DHES permit requirements, the discharged effluent is adding to the Clark Fork's nutrient and suspended solid concentrations and load. All tributaries are adding varying amounts of nutrients and suspended material to the river with the Missoula WWTP being another major contributor. Downstream the reservoirs at Thompson Falls, Noxon and Cabinet Gorge act as settling basins for much of the sediment and some of the nutrients, resulting in both secondary and cumulative impacts from the nutrients and suspended solids.

Most of the aesthetic problems attributable to the Frenchtown Mill were not substantiated. Foam occurred above and below the mill, however it had different characteristics below. Tests did reveal that undiluted effluent from Champion would foam, yet when mixed with riverwater, it would not foam. Champion is continuing to investigate ways to reduce foaming agents.

The DHES investigated reports that the mill was discharging unknown organic wastes, such as small wood fibers. All material collected or sent to the department was examined, but proved to be inorganic and organic matter and micro-organisms indigenous to the Clark Fork or to Champion's wastewater storage ponds.

The water in the eight mile long mixing zone is impacted by direct discharge and seepage from Champion's wastewater treatment facility. Montana regulations allow a mixing zone in which water quailty standards do not apply.

It is possible that organic compounds from Champion's effluent may be accumulating in the biota of the Clark Fork River. However, studies of algae and invertebrates in the river indicate no ill effects from bioaccumulations, if it is occurring in these organisms. Similarly it isn't known if these compounds are accumulating in fish nor what the effects of that accumulation in fish might be.

There were complaints of fish smelling and tasting bad during certain times of the year. Two separate taste tests revealed that fish exposed to high concentrations of effluent did not smell or taste as good as control fish, however the fish that were judged the best smelling and tasting were exposed to dilute solutions of effluent similar to those permitted in the river.

Thus, there are aesthetic problems in the Clark Fork River in the area of the mill, and these secondary and, in some cases, cumulative impacts do affect recreational use of the river. However, in most cases more research will be needed to define the cause of the impacts.

POTENTIAL GROWTH INDUCING OR GROWTH INHIBITING IMPACTS

The proposed action will not result in any growth inducing or growth inhibiting impacts.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF ENVIRONMENTAL RESOURCES

If Champion was able to meet every provision of the DHES discharge permit and never violate any aspect, it would still be adding to natural and cultural contributions of nutrients and suspended solids. Possibly technology will someday be able to prevent all contributions of these two elements, but until then, they remain irreversible and irretrievable commitments to environmental resources.

ECONOMIC AND ENVIRONMENTAL BENEFITS AND COSTS

Benefits:

1) Year around discharging will enable the Frenchtown Mill to continue to operate at its current production.

2) Continued operation of the mill provides a stabilizing element to the wood products industry in the region.

3) The economic influence of the mill benefits businesses and government in the Missoula area.

Costs

1) It adds to the quantities of nutrients and sediments flowing downstream.

2) Degradation within the authorized mixing zone must be considered an environmental cost.

SHORT-TERM USES OF MAN'S ENVIRONMENT VS. LONG-TERM PRODUCTIVITY OF THE ENVIRONMENT

Based on the information gathered by the DHES, Champion International should be able to discharge effluent throughout the year and not degrade water quality.

Monitoring is required, and designed to ensure permit compliance.

Even when discharging within the provisions of the permit, there will be impacts to the river. In the cases of nutrients and suspended solids, they will add to the concentrations and volumes already flowing downstream. Since there are only two years of extensive scientific information, some possible effects of the discharging might still be undiscovered or unconfirmed. Should further monitoring identify instream problems the permit would be revised appropriately.

The long-term quality of water in the Clark Fork basin can be influenced a little by the mill, particularly if the effluent is improved

or eliminated, however it is only a small part of the natural and cultural forces that influence the Clark Fork.

ALTERNATIVES

The DHES has three possible alternatives:

a) Deny the permit,

b) Approve the permit for discharging treated wastewater on a year around basis for five years based on the provisions of DHES discharge permit MT-0000035 or

c) Modify the current permit by including additional conditions.

RECOMMENDATION

The DHES recommends alternative two.

GLOSSARY

Aerated Stabilization Basin - At Champion, this consists of two ponds that have a total retention time of about eight days and use 12 aeration machines to add air to the ponded wastewater. One of the main uses of the ponds is to rid the wastewater of the BOD.

Aeration - The process of being supplied or impregnated with air. Aeration is used in biological treatment to dissolve oxygen in the wastewater. This dissolved oxygen is required by microorganisms as they feed on organic matter in the wastewater.

Anaerobic - Refers to life or activity in the absence of free oxygen.

Alluvium - Sediments, usually fine materials, deposited on land by a stream.

Aquifer - A water-bearing layer of rock or soil that will yield water in usable quantity to a well or spring.

Aquatic Macroinvertebrates - Animals without backbones living part of their life on or in stream bottoms.

Autotrophic - Organisms, including algae and higher plants, that are capable of using inorganic materials in the synthesis of living matter.

Background - Environmental conditions existing before or upstream from a source of contamination.

Baseline - A record of environmental conditions existing at a given point in time.

Bedrock - A general term for the consolidated (solid) rock that underlies soils or other unconsolidated material.

Benthic - Of or pertaining to the stream bottom.

Bioassay - The use of living organisms to test the effects of a substance.

Biological Oxidation - The process by which bacterial and other microorganisms oxidize complex organic materials to simpler compounds and use these for growth and energy.

Biochemical Oxygen Demand (BOD) - This is the oxygen needed for decomposition of organic matter in water. High BOD reduces oxygen in water and can cause stress to aquatic life. Scientifically, it is the quantity of oxygen used in the biochemical oxidation of organic matter in a specified time (five days) and at a specified temperature (20 degrees C).

Cellulose - The major component of the cell walls of all wood, straws, bast fibers and seed hairs. It is the main solid of woody plants and is the principal raw material of pulp, paper and paperboard.

Chemical Oxygen Demand (COD) - A measure of the oxygen-consuming capacity of organic and inorganic matter present in water or wastewater. It is expressed as the amount of oxygen consumed from a chemical oxidant in a specific test.

Chlorophyll a - The primary photosynthetic pigment in algae.

Clarifier - In wastewater treatment, a settling tank which removes solids from wastewater through gravitational settling. The settled material, called sludge, is removed from the tank bottom by a rake arm.

Color - Color in water may result from the presence of natural metallic ions (iron and manganese), humus, peat, plankton, weeds and industrial waste. With respect to standards, it refers to an American Public Health Association test for determining color intensity of water samples. Standards are prepared at various concentrations which later may be referenced as units of color, derived from flow and concentration.

Color Units or Standard Color Units (SCU) - A measure of color concentration in water.

Concentration - The strength or density of a substance in solution.

Cubic Feet Per Second (cfs) - Cubic feet per second is a measurement of volume of flow over time.

Digester - The vessel used to treat pulpwood with chemicals to produce pulp.

Diurnal - Throughout the day, around the clock.

Dissolved Oxygen - The amount of oxygen, expressed in milligrams per liter, dissolved in water.

Dissolved Solids - The total amount of dissolved material, organic and inorganic, contained in water or wastes.

Environmental Impact Statement (EIS) - A document that thoroughly reviews a proposed action and recommends possible courses of action. There is usually a draft and final EIS. In Montana, it is a legal provision of the Montana Environmental Policy Act.

Eutrophication - Pertaining to bodies of water, characterized by the accumulation of high concentrations of dissolved nutrients, often resulting in excess plant growth and periods of oxygen deficiency.

Fatty Acid - A naturally occurring organic compound of wood.

Fiber - The cellulosic portion of the tree used to make pulp, paper and paperboard.

Grab Sample - A sample collected at a single time and place.

Groundwater - All subsurface water, especially that part that is in the

zone of saturation.

Inorganic - Pertaining to or composed of chemical compounds that do not contain carbon as the principal element.

Kraft - A descriptive term for the (alkaline) sulfate pulping process which produces the pulp from which paper or paperboard are made.

Lignin - A substance that together with cellulose forms the woody cell walls of plants and cements them together; a colorless to brown, non-degradable organic compound of wood which is removed during pulping and a common component of "color."

Linear - A relationship between two variables which can be approximated by a straight line.

Linerboard - A paperboard made at Champion's Frenchtown Mill and used as the facing material in the production of corrugated and solid fiber shipping containers.

Loading - The progressive accumulation of dissolved or suspended material in a stream.

Mean - A single number that typifies a set of numbers, such as the arithmetic mean, the geometric mean or the expected value.

Milligrams Per Liter (mg/l) - Milligrams per liter is a measure of concentration.

Nutrients - Elements or compounds essential as raw materials for the growth and development of an organism.

Organic - Living or derived from living organisms, matter which includes carbon as one of its component elements.

pH - A measurement of the relative acidity or alkalinity of water.

Periphyton - Attached, bottom-dwelling algae.

Potentiometric Surface - A surface that represents the total head in an aquifer, that is, it the height above the datum plane at which the water level stands in tightly cased wells that penetrate the aquifer.

Preliminary Environmental Review (PER) - This is similar to the EIS, however it is not as detailed. It often is done to see if an EIS is needed.

Pulp - Cellulosic fibers after conversion from wood chips.

Rapid Infiltration - Adding wastewater to a natural gravel basin and allowing the basin to drain and dry.

Resin - A special additive used to produce wet-strength in paper or paper-

board.

Resin Acid - A naturally occurring organic compound in wood.

Sag - A condition in streams that occurs when organic wastes are introduced which use some of the dissolved oxygen present in the stream; graphically depicted as a "sag" in the normal curve for dissolved oxygen.

Seepage - The slow movement of water through small openings and spaces in the surface of unsaturated soil into or out of a body of surface or subsurface water.

Slug - See Synoptic.

Substrate - A material on which an aquatic organism adheres.

Suspended Solids - A mixture of fine, nonsettling particles of any solid within water, the particles being dispersed, while the water is continuing to move.

Synoptic - A downstream series of water samples which when timed according to rate-of-flow and distance, enables scientists to sample the same "slug" of water as it flows downstream.

Total Suspended Solids (TSS) - This is a measure of the concentration of suspended matter in a body of water. It includes both organic (both living and dead organisms) and inorganic (clay and silt) materials.

Volatile Suspended Solids (VSS) - Refers to the concentration of organic material in a sample of suspended solids.

Water Column - From the bottom of a stream or reservoir to the water surface.

Water Table - The level below which the ground is saturated with water.

Water Quality - The fitness of water for use, being affected by physical, chemical and biological factors.

REFERENCES

Air Quality Bureau, Draft Environmental Impact Statement for the Proposed Expansion of the Hoerner-Waldorf Pulp and Paper Mill at Missoula, Montana, Environmental Sciences Division, Montana Department of Health and Environmental Sciences, Helena, Montana, November 1974.

Air Quality Bureau, Final Environmental Impact Statement for the Proposed Expansion of the Hoerner-Waldorf Pulp and Paper Mill at Missoula, Montana, Environmental Sciences Division, Montana Department of Health and Environmental Sciences, Helena, Montana, November 1974.

Alt, David D. and Hyndman, Donald W., Roadside Geology of the Northern Rockies, Mountain Press Publishing Co., Missoula, Montana, 1972.

American Fisheries Society. 1979. A review of the EPA Red Book: Quality Criteria for Water. Water Quality Section, American Fisheries Society, Bethesda.

American Public Health Association, American Water Works Association, and the Water Pollution Control Federation. 1981. Standard methods for the examination of water and wastewater, Fifteenth edition, 1980. APHA, Washington, D.C. 1134 pp.

Bahls, L.L. 1979. Benthic diatom diversity as a measure of water quality. Proc. Mont. Acad. Sci. 38:1-6.

Bahls, L., M. Fillinger, R. Greene, A. Horpestad, G. Ingman and E. Weber. November 1979. Biological water quality monitoring: Northwest Montana, 1978-1979. MDHES, Helena. 59 pp.

Bahls, L.L. G.L. Ingman and A.A. Horpestad. February 1979. Biological water quality monitoring: Southwest Montana, 1977-1978. MDHES, Helena. 60 pp.

Bahls, L.L. and E.E. Weber. In Press. Benthic diatom associations as indicators of water quality in the Clark Fork River drainage, Montana. Proceeding of the Symposium on Biomonitors, Bioindicators and Bioassays of Environmental Quality, 66th Annual meeting of the Pacific Division, American Association for the Advancement of Science, June 9-14, 1985, Missoula, Montana.

Boettcher, Arnold J. and Gosling, Arthur W., Bulletin 104: Water Resources of the Clark Fork Basin Upstream from St. Regis, Montana, U.S. Geological Survey and Montana Bureau of Mines and Geology, Montana College of Mineral Sciences and Technology, Butte, Montana, 1977.

Botz, M.K., Casne, E.W. and Pasichnyk, M.J., Water Quality Inventory and Management Plan: Lower Clark Fork River Basin, Montana, Water Quality Bureau, Environmental Sciences Division, Department of Health and Environmental Sciences, Helena, Montana, July 1976.

Botz, M.K., Casne, E.W. and Pasichnyk, M.J., Water Quality Inventory and Management Plan: Upper Clark Fork River Basin, Montana, Water Quality Bureau, Environmental Sciences Division, Department of Health and Environmental Sciences, Helena, Montana, July 1975.

Brietkrietz, Alex, Konizeski, R.L. and McMurtrey, R.G., Bulletin 47: Geology and Groundwater Resources of the Missoula Basin, Montana, Montana Bureau of Mines and Geology, Montana College of Mineral Sciences and Technology, Butte, Montana, July 1965.

Bugbee, Bruce A. and Associates, Inventory of Conservation Resources Missoula County, Montana, prepared for the Missoula County Commission, August 1985.

Burckley, et. al, Modern Earth Science, Holt, Rinehart and Winston, Inc., 1969.

Champion MPDES file, yearly discharge summary 9/3/85 letter from Bill Henderson to Steve Pilcher

Corps of Engineers, U.S. Army, Special Flood Hazard Information, Clark Fork: Vicinity of Missoula to Alberton, Montana, prepared by the Washington District for Missoula County, Montana, Seattle, Washington, August 1973.

Division of Forestry, Department of State Lands and Intermountain Forest and Range Experiment Station Region I, U.S. Forest Service, Timber Resources of Mineral, Missoula and Ravalli Counties, April 1983.

Economic Research Service, Forest Service and Soil Conservation Service, Clark Fork of the Columia River Basin Cooperative Study, U.S. Department of Agriculture and Montana Department of Natural Resources and Conservation, 1978.

Ekisola, O.F. 1985. Rate of instream sedimentation of fine particulate organic matter as a measure of water quality degradation by a pulp/paper mill. University of Montana, Missoula.

Firebaugh, John, Personal Communication: Terrestrial and Aquatic Life, Montana Department of Fish, Wildlife and Parks, Missoula, Montana, October 30, 1985.

Greene, J.C., M. Long and C.L. Bartles. October 1985. Results of algal assays performed on wastes collected from the lower Clark Fork River system at stations below Milltown Dam to below Noxon Dam. Report I: December 10-14, 1984 sampling. USEPA, Corvallis, Oregon 9 pp.

Institute of Paper Chemistry. 1983-1985. A benthic invertebrate water quality survey of the Clark Fork River in the vicinity of Missoula, Montana, 1983 to 1985. Progress Reports Nos. 31-33, prepared for Champion International Packaging Division, Frenchtown.

Final Environmental Impact Statement for the Proposed Expansion of the Hoerner-Waldorf Pulp and Paper Mill at Missoula, Montana, November 6, 1984, Department of Health and Environmental Sciences

Grimestad, G. 1977. A Geo-Hydrologic Evaluation of an Infiltrative Disposal System for a Kraft Process Pulp and Paper Mill Liquid Effluents. University of Montana PhD Thesis, Missoula, Montana

Johnson, Howard E. and Knudson, Ken, Clark Fork River - Lake Pend Oreille Basin Project: An Aquatic Resource Evaluation and Work Plan, Montana Governor's Office, Helena, Montana, June 1985.

Kicklighter, D.W. and J.A. Stanford, November 1985. The use of riffle community metabolism as the measure of water quality degradation in the Clark Fork River, Montana. Flathead Lake Biological Station, University of Montana, Bigfork. 88 pp.

Lange-Bertalot, Horst. 1979. Pollution tolerance of diatoms as a criterion for water quality estimation. Nova Hedwigia, Bieheft 64: 285-304.

Lowe, R.L. 1974. Environmental requirements and pollution tolerance of freshwater diatoms. EPA-670/4-74-005.

Malouf, Carling I., Contributions to Anthropology, No. 7: A Study of the Prehistoric and Historic Sites Along the Lower Clark Fork River Valley, Western Montana, Department of Anthropology, University of Montana, Missoula, Montana, May 1982.

Missoula City-County Planning Staff, Missoula County Comprehensive Plan, Missoula, Montana, 1975.

Mills, W.B., J.D. Dean, D.B. Procella, S.A. Gherini, R.J.M. Hudson, W.E. Frick, G.L. Rupp and G.L. Bowie. September 1982. Water quality assessment: A screening procedure for toxic and conventional pollutants. Part 1. EPA-600/6-82-004a.

National Academy of Sciences, National Academy of Engineering. 1973. Water quality criteria 1972. EPA Ecol. Res. Series EPA-R3-73-033, U.S. Environmental Protection Agency, Washington, D.C.

National Council of the Paper Industry for Air and Stream Improvement. 1978 A. Characterization of dispersed residual solids in biologically treated pulp and paper mill effluents. Stream Improvement Technical Bulletin No. 303.

National Council of the Paper Industry for Air and Stream Improvement. 1978B. An investigation of the extent of residual biosolids deposition in quiescent receiving waters. Stream Improvement Technical Bulletin No. 304.

National Council of the Paper Industry for Air and Stream Improvement. 1978C. A study of the fate of biosolids from biologically treated effluent in laboratory and constructed streams. Stream Improvement Technical Bulletin No. 308.

National Council of the Paper Industry for Air and Stream Improvement. 1982. Effluent foam control practices. Technical Bulletin No. 378.

National Council of the Paper Industry for Air and Stream Improvement. 1983. A study of foaming and its possible causes on the Androscoggin River. Technical Bulletin No. 395.

Patmont, C.R., G.H.J. Pelletier and M.E. Harper. June 1985. Phosphorus attenuation in the Spokane River. Prepared for the State of Washington Department of Ecology, Olympia. 144 pp.

Perry, Eugene S. Bulletin 26: Montana in the Geologic Past, Montana Bureau of Mines and Geology, Montana College of Mineral Sciences and Technology, Butte, Montana, March 1962.

Schwab, David, "Wastewater Discharge Permit", State Historic Preservation Office, Montana Historical Society, Helena, Montana, November 4, 1985.

Shewman, F., L. Bahls and A. Horpestad. March 1984. Preliminary environmental review, proposed permit modification, Champion International. MDHES, Helena. 44 pp.

U.S. Environmental Protection Agency. "Development Document for Effluent Limitations Guidelines and Standards for the Pulp, Paper and Paperboard", EPA 440, 1-82/025, October, 1982.

U.S. Environmental Protection Agency. "Effect of Hydrogen Sulfide on Fish and Invertebrates - Part I - Acute and Chronic Toxicity Studies" (EPA-600/3-76-062a, July 1976)

U.S. Environmental Protection Agency. 1977. Quality criteria for water, Office of Water and Hazardous Materials, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Forest Service, Forest Habitat Types of Montana, Intermountain Forest and Range Experiment Station, U.S. Department of Agriculture, Ogden, Utah, May 1977.

Water Quality Bureau , Department of Health and Environmental Sciences. October 1984. Montana water quality--1984. Helena. 128 pp.

Weber, C.I. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. National Environmental Research Center, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati.

Weston Consultants. October 1985. "Evaluation of Alternative Technologies for Wastewater Treatment", prepared for Champion International Corporation, Missoula, Montana.

Weston, Inc. April 1985. Evaluation of alternative technologies for wastewater treatment, Champion International Corporation, Frenchtown Mill, Missoula, Montana.

Woods, P.F., S.A. Frenzel and W.H. Low. July 1985. Susceptibility of Lake Pend Oreille, Idaho to cultural eutrophication: A project proposal. U.S. Geological Survey, Boise, Idaho. 27 pp.

10/24/85 letter from Larry Weeks to Donald G. Willems

Subsidiary references from 1984 Hoerner Waldorf EIS

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